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# ***USSR Space Life Sciences Digest***

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The goal of this publication is to inform personnel of the NASA Life Sciences Division of important developments in the Soviet Space Life Sciences Program in a manner that eliminates the task of locating and reviewing the voluminous Soviet literature.

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## INTRODUCTION

Soviet scientists are making significant contributions to the field of space medicine and biology through their active manned space program, frequent biosatellites, and extensive ground-based research. It is important that U.S. space life scientists be familiar with the literature generated by the Soviet program. The purpose of this document is to provide an overview of the developments and direction of the USSR Space Life Sciences Program.

Information concerning the Soviet space program makes its way into U.S. information banks and publications via a number of routes. While many agencies survey the Soviet literature and produce helpful listings and translations, no agency reviews the full scope of Soviet life science literature pertinent to the space program, and no agency is specifically charged with the task of evaluating and integrating any of this information. This Quarterly Digest is designed to bridge that gap.

The information contained in this Digest is primarily obtained from the following sources:

- Abstracts in Soviet space biology and medicine provided by the Library of Congress, Science and Technology Division.
- *Aerospace Medicine and Biology*—A continuing bibliography (NASA SP-7011).
- *Scientific and Technical Aerospace Reports*—A bibliography produced by the Scientific and Technical Information Office, NASA.
- Foreign Broadcast Information Service, Volume III, Soviet Union—NTIS. Abbreviated FBIS.
- Daily Soviet News Abstracts Publication—Translated abstracts of news items from the Soviet press. Published by Foreign Technology Division, Battelle Columbus Laboratories, Abbreviated Daily SNAP.
- *Space Biology and Aerospace Medicine*—A complete translation of the Russian language monthly journal *Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina*, published in the U.S. by Joint Publications Research Service.
- *USSR Report, Biomedical and Behavioral Science*—Translated abstracts in biochemistry, radiobiology, aerospace biology, and medicine, from a variety of Russian language sources. Published in the U.S. by Joint Publications Research Service.
- *USSR Report, Space*—Translated abstracts of formal scientific reports and news items on the Soviet space program, from a variety of foreign language sources. Published in the U.S. by Joint Publications Research Service.
- *Aviation Week & Space Technology*—Weekly periodical published by McGraw-Hill, Inc. Abbreviated *AW&ST*.
- *Astronautics and Aeronautics*—Monthly periodical published by the American Institute of Aeronautics and Astronautics, Inc.
- *Aviation, Space and Environmental Medicine*—Monthly periodical published by the Aerospace Medical Association.
- *Spaceflight*—Monthly periodical published by the British Interplanetary Society.

## HIGHLIGHTS

### Launches and Recoveries

- There were no launches or recoveries of manned vehicles or biosatellites during the period October-December 1981 (nor were any manned or Earth-orbiting biological missions in progress). However, two automatic interplanetary probes of the "Venera" series were launched. Venera-13 and -14, launched on 30 October and 4 November, will continue studying the atmosphere and surface of Venus. Venera-13 will carry out the first compositional analysis of Venutian soil. En route, the stations will conduct studies of X-rays, gamma radiation, and magnetic fields in space, and will examine characteristics of the solar wind, cosmic rays, and the interplanetary plasma. The two stations are expected to reach Venus on March 1 and 5, 1982, respectively, landing on an area selected through use of U.S. Pioneer-Venus radar images of the planet.

### New Programs

- The quality and availability of scientific instruments and equipment has been a problem for Soviet researchers. To correct this deficiency, four new complexes have been planned to support different fields of science. The first, an experimental facility for the USSR Academy of Sciences' Institute of Space Research, is already under construction. Three other industrial facilities will enter construction in 1982; these will manufacture lasers, physics research instruments, and other analytical instruments.

### Mission News

- The Salyut 6/Soyuz 1267 complex continues to function normally in an automatic mode with telemetric monitoring and control from the ground. As of 29 September, the Salyut station had been in orbit for four years and had completed 23,030 orbital revolutions. To date, 16 crews have carried out more than 1,600 experiments aboard the station. The 34-ton Salyut/Soyuz complex is now being used to test design characteristics for future orbiting complexes in which Soyuz-like modules dedicated to astronomical, biological, energy, and materials-processing research will dock with a manned station.

It had been expected that Salyut 6 would be replaced by a new station, Salyut 7, before the next series of manned missions began. However, if it continues to function smoothly, the long-lived Salyut 6 will be used for the Soviet-French mission scheduled for launch in May or June of 1982. The three-member primary and back-up crews for this joint mission completed the theoretical first stage of cosmonaut training in September, and are now engaged in the second, or operational, stage of training.

- The cosmonaut training director, V. Shatalov, reports that there is currently a reserve of 50 Soviet cosmonauts, with 16 now in various stages of training. For weightlessness training, the Cosmonaut Training Center has acquired an IL-76 aircraft for use in performing Keplerian maneuvers. The new airplane permits the execution of 15 maneuvers in a single flight, as compared to the 5 that were possible with the TU-104 which it replaced. In addition, the periods of simulated weightlessness are more prolonged. The laboratory cabin can hold full-size mockups of spacecraft.



## Meetings

- A joint conference on human adaptation to extreme environmental conditions was held in September by the USSR Academy of Medical Sciences' Scientific Council for Planning and Coordinating Research in Molecular Biology and Molecular Genetics in Medicine, and the Presidium of the Academy's Siberian Branch. The subject of the meeting was "The Role of the Nervous System (Molecular-Biological Aspects) in the Adaptation and Compensation of Functions of the Organism." The ultrastructural and biophysical bases of adaptational and compensatory mechanisms were discussed.
- An international conference on "Measurements in Medicine and Biology," held in Suzdal' in October, included scientists and specialists from 13 countries. Speakers reported advances in medical instrument building, including automated psychophysiological complexes and life support systems, and studies directed at bioelectric activity and holographic endoscopy.
- The second all-Union conference on "Problems of Technology in Medicine" was held in Tol'yatti. Presented papers included one entitled "The Interaction of Non-Ionizing Electromagnetic Radiation with Living Systems." Topics in a special section of the conference included the interaction of electromagnetic and other physical fields generated by instruments with biological systems ranging from the cellular to the organismic level.
- The "First All-Union Conference on Applied Radiobiology" was held in Kishinev in early November.
- At a symposium entitled "Ultrasound in Biology in Medicine," held in Tashkent, recent findings on the therapeutic value of ultrasonic vibrations were presented. The hypothesis was advanced that the beneficial effect on tissue and systems is due to the formation of biogenic stimulants in the organism.

(Material in the "Highlights" is drawn from SWB, October-December, 1981; FBIS, October-December, 1981; Daily SNAP, October-December, 1981; and AW&ST, October-December, 1981.)

## GROUND-BASED RESEARCH

### Space Medicine and Physiology

#### Comprehensive Reviews

*Key words: space technology, safety, biomedical research*

Scientific results reported by participants in the 8th Gagarin Lecture Series in 1978 have now been published as *Scientific Lectures on Aviation and Cosmonautics in 1978* (Ishlinskiy et al., 1980). The collection contains articles on aviation/space engineering and technology, life support systems, provisions for crew safety, flight control, and biomedical research conducted aboard manned orbital stations. Among the authors are such notables of the Soviet space program as O.G. Gazenko, V.V. Parin, V. Shatalov, G. Beregovoy, and A. Leonov.

*Key words: space technology, cosmonaut training, biomedical research, space applications*

Papers and reports delivered during the 9th and 10th series of Gagarin lectures, which took place in 1979 and 1980, have been published (Ishlinskiy, 1981). Like its predecessor in the series, this volume incorporates discussions of problems and achievements in space technology, development of onboard systems, inflight research, and the future of the space program. Results of the 175-day and 185-day missions, which took place during the two years covered by this volume, are included. Materials processing and other research on space applications of economic significance are given increasing emphasis in this series, as they are in the Soviet space program in general.

*Key words: Tsiolkovskiy, biomedicine, adaptation*

One of the early, seminal figures in Russian science relating to the development of the space program was K.E. Tsiolkovskiy. An engineer by training, Tsiolkovskiy provided much of the philosophical direction and impetus of the space program, in addition to making important basic contributions in a variety of areas central to cosmonautics: life support, adaptation, the biomedical effects of weightlessness and other spaceflight factors. Each year a series of lectures is presented which is "dedicated to development of the scientific heritage and ideas" of Tsiolkovskiy. Proceedings of the 12th and 13th lecture series, held in 1977 and 1978, were published in combined form in 1979 (Khazen et al.). This volume examines problems of space medicine and biology as they relate to human adaptation to long-term spaceflight. Approximately 40 articles by many of the most prominent Soviet space researchers are presented, dealing with nearly as many different aspects of space biomedicine.

*Key words: Tsiolkovskiy, space exploration, philosophical considerations*

K.E. Tsiolkovskiy is considered to be "the father of Soviet cosmonautics." The 14th lecture series held to commemorate his achievements took place in 1979, and concerned the "Exploration of Space and Correlation Between Sciences" (Ursul, 1980). One section of the proceedings is

concerned with philosophical problems relating to space exploration. Articles delve into such issues as "anthropocosmism" (as formulated by Tsiolkovskiy), the need for "cosmization" of human activities, the effects of space consciousness on human social thought and self-concepts, the impact on international relations, and aspects of the search for (and possible contact with) extraterrestrial intelligence.

*Key words: V.V. Parin, space medicine, physiology, cardiology*

The Second Lecture Series in Memory of Academician V.V. Parin was held in April 1981 (Fedorov, 1981). Subject areas included the disciplines in which Parin made eminent contributions during his lifetime: space medicine, clinical physiology, and experimental cardiology. Particular attention was focused on currently pressing problems of space medicine, such as adaptive circulatory and hemodynamic changes seen during long-term exposure to weightlessness, the use of pharmacological agents, and forecasting of pathological states. The effects of stress, hypokinesia, and various countermeasures, and the use of innovative techniques and instrumentation are discussed.

### **Cardiovascular System**

*Key words: myocardium, cardiac cycle, regulation*

Relatively new techniques have made it possible to study the processes that occur in the myocardium within the space of a single heartbeat. Frolov, Bogdanova, and Kazanskaya (1981) have published a book in which they examine the electrophysiological, metabolic, and ultrastructural dynamics of the cardiac cycle under both normal and pathological conditions. They explain the unity of heterometric and homeometric mechanisms of regulation of myocardial contractility on the basis of spatial correlations of ultrastructures of the myocardium during systole and diastole. This is one of the first attempts to use a synthetic approach to the analysis of functional mechanisms of the cardiac cycle.

*Key words: myocardium, cardiac function, muscular activity*

Butchenko (1979) used electrocardiography and a variety of functional tests to assess the general health of the heart in 927 individuals differing in the degree of exercise in which they customarily engaged. One group, consisting of healthy athletes, engaged in adequate muscular activity. Another group consisted of excessively active athletes, or those whose sports subjected them to chronic physical stress. A third group was comprised of individuals who led a sedentary life, with insufficient activity. Tests were performed with graded physical exercise, breathholding, and breathing of various mixtures of oxygen and carbon dioxide. Individuals with *adequate* muscular activity presented large functional reserves and adaptive capabilities of the heart, along with improved functions, excitation, metabolism, and neural and humoral regulation of cardiac function. Those who were *excessively* active displayed decreased functional reserves and adaptability of

the heart, due to pathological hypertrophy and myogenic dilatation of the myocardium; a number of disturbances of cardiac function were also found. Those with *insufficient* muscular activity presented a drastic decrease in functional reserves and adaptability of the heart, showing dystrophic and sclerotic changes in the myocardium.

*Key words: mental work, cardiac rhythm, circulation, regulation*

Conventional methods of examining the cardiovascular system (pulse rate, arterial pressure, ECG, etc.) are not adequate for detection of functional changes that occur during mental work, with its characteristic lack of strong emotiogenic factors and distinctive features such as shortage of time, irregular pace, and threat of emergency situations. Kovaleva (1979) surveyed several groups of mathematicians differing in intensity of work, but all of whose work was characterized by prolonged mental tension and hypokinesia. Mean arterial pressure and heart rate were found to be the same in all groups throughout the workday. However, when an autocorrelation function analysis of heart rate was performed and type of circulatory self-regulation was determined, differences based on work intensity were found. Specifically, the period of slow waves of cardiac rhythm was seen to increase with increase in the intensity of work. In addition, self-regulation of circulation changed from the cardiac type at the start of the work period to the vascular type at its end. (This was most pronounced in the maximum-work-intensity group.) The vascular type of circulation is considered the least stable and the most likely to produce hypertension. Medical histories of the subjects confirmed these findings: Essential hypertension and vegetovascular dystonia were observed 1.8 and 3.0 times more often (respectively) in the maximum-intensity group than in the minimum-intensity group.

*Key words: cardiac rhythm, baroreflex regulation, noninvasive method, mesatron*

Temirov and associates (1980) devised a simple and comparatively atraumatic method of measuring human baroreflexes, based on analysis of the changes in systolic frequency that occur when hypertension is briefly induced by intravenous administration of the drug mesatron. The rate and time of administration (in doses of 0.002-0.004 mg/kg) are selected so that the rise in mean arterial pressure comprises 20-40 mmHg with a duration of 20-30 sec. The regression coefficient of measured systolic frequency changes can be used as an index of baroreflex regulation of cardiac rhythm. Results obtained with this technique agree closely with results obtained elsewhere using direct measurement of arterial pressure to evaluate baroreflex bradycardia.

*Key words: postural changes, blood pressure, jugular, right atrium*

Change in position of the body is associated with changes in the hydrostatic component of blood pressure of peripheral vessels, including the jugular vein. In order to study such pressure changes and their correlation with intracranial hemodynamics, particularly in the antiorthostatic position, Katkov, Chestukhin, Rumyantsev et al. (1981) subjected 10 subjects to head-up and head-down tilts at 10°, 30°, and 75° for 5 min each. Blood pressure in the upper bulb of the internal jugular vein and the right atrium was measured, along with blood acid-base equilibrium,

hemoglobin content, and oxygen saturation. In the 75° head-up position jugular vein pressure decreased, but remained positive in most cases, whereas atrial pressure dropped to negative levels. In the head-down position the jugular pressure increased in proportion to angle of tilt, reaching 32.2 mmHg at 75°; atrial pressure increased in some subjects and decreased in others. Throughout the test, the oxygen arteriovenous difference in the brain and the acid-base equilibrium in outflowing blood remained essentially unchanged. The authors attributed this stability to autoregulation of the cerebral blood flow adequately meeting metabolic requirements. By contrast to immersion, right atrial pressure changes in the antiorthostatic position are quite low.

## **Respiratory System**

*Key words: hypercapnia, ventilation, recovery*

The occurrence of hypercapnia is a possibility during spaceflights. To test the effect of progressive hypercapnia on pulmonary ventilation, Ivanov (1981) used a spiograph in conjunction with a carbograph to record CO<sub>2</sub> concentration. A pneumotachograph sensor and printer allowed the determination of respiratory rate and minute volume (MV). Graphing the correlation between alveolar CO<sub>2</sub> partial pressure (p<sub>A</sub>CO<sub>2</sub>) and MV gave a curve of the recovery period of ventilation after hypercapnia. Resistance to hypercapnia was determined from the point at which the subject refused to continue breathing from the spiograph. The functional capacity of the respiratory center could then be derived. The increase in pulmonary ventilation seen in these tests is proportionate to the increase in p<sub>A</sub>CO<sub>2</sub>. The recovery occurs in three phases, with a more marked increase in MV in the second phase and a stable MV level in the third phase. The duration of recovery is largely determined by the rate of regression of the excitatory process triggered in the respiratory center by hypercapnia.

*Key words: fluid redistribution, pulmonary edema, ventilation*

Agapov (1979) investigated the dynamics of fluid redistribution in pulmonary tissue under normal and pathological conditions. Mathematical modeling was used to determine the interrelationship between the circulatory system, respiration, and water-salt metabolism during pulmonary edema. The model shows that an increase in resting blood pressure causes an increase in the volume of free fluid in the lungs, resulting in a significant decrease in oxygen saturation of the blood and elasticity of the pulmonary tissue, as well as an increase in overall respiratory energy expenditure. Physical work intensifies these effects. A decrease in oxygen saturation in pathology causes no appreciable increase in pulmonary ventilation at rest or during work.

## **Metabolism**

*Key words: lipid metabolism, pressurized chamber, physical activity*

Research has indicated that  $\alpha$ -lipoproteins ( $\alpha$ -LP) may represent an "inverse risk factor" for cardiac ischemia: the lower the content of this fraction and the lower the percentage of blood

serum  $\alpha$ -cholesterol ( $\alpha$ -C) contained in it, the higher the risk of disease. A decrease in  $\alpha$ -LP has been seen in subjects confined to pressurized chambers. To evaluate lipid metabolism under such conditions, Bychkov and Khokhlova (1981) determined the ratio of  $\alpha$ -LP to total cholesterol ( $\alpha$ -LP/C) in 115 subjects held in small pressurized chambers for up to 42 days. A decrease in the coefficient was considered to indicate adverse changes in lipid metabolism. Such decreases were found in the experiment, as well as in data from similar previous experiments; the severity of change depended on time spent in the chamber. To eliminate the effect of other factors relating to confinement (altered diet, change in atmosphere, lack of exercise), the authors evaluated data from earlier studies. They concluded that the spaceflight diet has no effect on lipid metabolism; nor did confinement to a pressurized chamber cause adverse changes, as long as physical exercises were performed. Hypokinesia (bedrest), however, did produce a significant drop in  $\alpha$ -LP/C. The authors conclude that in both cases the decrease in physical activity is responsible for the adverse changes in lipid metabolism.

### Hypokinesia

*Key words: antiorthostatic bedrest, exercise, vitamin excretion*

Hypokinesia has been shown to produce significant metabolic changes, particularly in vitamin metabolism. But there have been no studies of the effect on vitamin metabolism of countermeasures used in prolonged antiorthostatic hypokinesia. Bychkov and Korshunova (1981) studied the excretion of ascorbic acid (vitamin C), thiamin ( $B_1$ ), and 4-pyridoxic acid ( $B_6$ ) in subjects undergoing 182-day -4.5° bedrest with and without exercise at different loads. Controls used no preventive measures; two other groups exercised at 200 and 400 kcal/day (after the 1st week). No appreciable changes in vitamin excretion were seen during the first week; all groups showed an increase in excretion on the 30th day, even with exercise. In controls, ascorbic acid excretion was subsequently reduced,  $B_1$  excretion remained the same, and  $B_6$  excretion increased. Excretion of all three vitamins was somewhat more stable in the second group (200 kcal/day) than in the third group. This is attributed to the conformity of the energy cost of their exercise regime with their normal energy expenditure. This finding suggests the need to condition subjects to anticipated exercise countermeasures programs in advance, so as to avoid additional strain on adaptive mechanisms.

*Key words: 182-day bedrest, postural equilibrium, visual analyzer*

It has been difficult to study the impact of functional changes in sensory systems on disturbances of postural equilibrium seen in cosmonauts. Ground-based studies of equilibrium function have previously been conducted only during the recovery period. Kotovskaya, Gavrilova, and Galle (1981) examined the dynamics of such changes during 182-day hypokinesia, including the role of visual, vestibular, and proprioceptive stimulation. Test subjects were examined stabilographically before and during the -4° bedrest period. During the first 30 days they showed significantly impaired equilibrium (bodily vacillation), but this later stabilized. After 50 days of hypokinesia, equilibrium disturbances increased significantly only with eyes shut. There appeared to be a changing involvement of the visual analyzer during the study: The role of vision in positional

regulation decreased during the first 90 days and increased during the second half of the experiment. Provocative tests suggest that bedrest-related impairment of equilibrium results from vestibular changes and deconditioning.

*Key words: sympathoadrenal system, immersion, acceleration*

The sympathoadrenal system (SAS) plays an important part in the development of adaptive reactions under weightlessness or simulated reactions. Davydova, Tigranyan, and Shul'zhenko (1981) examined SAS activity during water immersion and in response to accelerations. Subjects underwent 7 days of immersion, with half being exposed to 15-min periods of  $+3 G_z$  acceleration 7 days before and 1 day after immersion. A finding of increased hormonal and decreased transmitter activity during immersion indicated an emotional stress reaction to the test; this was more pronounced in the group that did not experience acceleration. Acceleration appeared to moderate the SAS reaction by stimulating the system. Normalization of SAS activity appeared by the 3rd day in the acceleration group and the 5th day in the immersion-only group.

*Key words: immersion, head-down tilt, acceleration, blood enzyme activity*

One of the aspects of deconditioning associated with hypodynamia is a decreased resistance to acceleration. It is thought that this and other decrements may result partly from changes in biochemical constants that produce an impairment of enzymatic coordination of different elements of metabolism of certain functional systems. Vetrova and associates (1981) investigated blood enzyme activity during exposure to accelerations before and after simulated weightlessness. When subjects were exposed to either immersion or head-down tilt for 7 days, the activity of most blood enzymes (malate, isocitrate dehydrogenase, and creatinine phosphokinase) decreased, while others (alanine and aspartate aminotransferase) remained generally unchanged. Exposure to  $+3 G_z$  accelerations 7 days before and immediately after the hypodynamic period elicited increases in the activity of nearly all enzymes; but the increases were significantly more pronounced in the postexperimental acceleration. The authors tentatively attribute this finding to an increase in cell membrane permeability under the influence of acceleration, with a greater change in permeability occurring after hypodynamia. The increased vulnerability to acceleration after immersion or hypokinesia would therefore be referable partly to changes in cell membranes occurring during the hypodynamic period.

*Key words: general treatise, biological aspects*

The book *Hypokinesia*, by Kovalenko and Gurovskiy (1981), presents a general treatment of the basic aspects of the problem of restricted motor activity and force loads. The book takes a general biological approach to the problem, drawing upon clinical, physiological, biochemical, and morphological data. It is directed particularly at specialists in space, marine, and sports medicine. Chapters address the following: (1) modeling and methodology for clinical studies; (2) gas and energy metabolism; (3) morphology and biochemistry of the heart; (4) muscular system; (5) bone system; (6) pathological physiology. The latter chapter features an original general scheme of the pathogenesis of hypokinesia.

## Lower Body Negative Pressure

*Key words: local negative pressure, occlusion cuffs, intravascular pressure*

The question of how preventive measures such as negative pressure and occlusion cuffs affect intravascular pressure has not previously been explored. Katkov et al. (1981a) used catheterization to examine the effects of these measures on intravascular pressure in the leg of a healthy subject. Local negative pressure (-50 and -100 mmHg) was applied above the knee and occlusion cuffs (+40 and +60 mmHg) were placed on the leg as close as possible to Poupart's ligament. Catheters were inserted in the femoral artery and vein and the arteries and veins at the back of the foot. Arterial pressure remained unchanged in all tests. With negative pressure, venous pressure in the back of the foot did not change, but pressure in the femoral vein decreased. With exposure to occlusion cuffs the venous pressure in the back of the foot increased noticeably, while it decreased slightly in the femoral vein. The authors conclude that while these measures can reproduce the effects of gravity on blood volume and blood flow, they are not effective in reproducing the most characteristic gravitational effects: changes in intravascular pressure gradients.

*Key words: lower body negative pressure, local negative pressure, central circulation*

Katkov et al. (1981b) examined the effects of different modes of lower body negative pressure and local negative pressure (LNP) on central circulation, oxidative metabolism, and blood acid-base equilibrium, and compared those effects with hemodynamic changes seen during orthostatic test. Catheters were implanted in the pulmonary and radial arteries of subjects exposed to one hour of head-down position at -20°. LBNP and LNP were applied at -30 and -60 mmHg and then at -50 and -100 mmHg, for 15-20 min in each regimen. Changes in parameters of circulation and oxygenation of mixed blood were similar with both preventive measures, although they differed in degree for some functions (central venous pressure, pulmonary artery pressure). The most marked changes in parameters were seen with the lesser negative pressure regime. Apparently the low levels of decompression are sufficient to stimulate low-pressure receptors of the cardiopulmonary system. Only high levels of LBNP are capable of stimulating sinoaortic receptors and causing large additional incremental changes.

## Vestibular System

*Key words: semicircular canals, rotating chair, analysis of forces*

Vorob'yev (1981) performed a mathematical analysis of the mechanical forces acting on the human semicircular canals during experiments involving rotating chairs and variable inclinations of the head. Results indicated that, with double rotation, displacement of the endolymph and dislocation of the cupula in the semicircular canals are determined not by precessional or cross-related angular velocities, but by the normal angular accelerations, which can be easily calculated. The method of analysis is applicable to other systems of rotation besides rotating chair.



*Key words: semicircular canals, endolymph, rotation*

A working model of the human semicircular canals was developed by Gurfinkel' and Petukhov (1977). It was used successfully to conduct experiments to clarify the hydrodynamics of endolymph movement in the canals, at rest, and at a constant angular acceleration of  $3-100^\circ$  per square cm. Hydromechanical relationships established in the movement of endolymph in the semicircular canals indicate that in rotation not only the horizontal canal but also the two vertical canals are simulated. Studies of vestibular function in sinusoidal rocking revealed that endolymph moves asymmetrically in opposite directions. The authors attempt to correct Steinhausen's equation to account for this asymmetry, which seems to indicate a buildup of differential deviations in the sensors of the vestibular apparatus.

## **Acceleration**

*Key words: flight control, performance quality, tracking errors*

Using a rotating chair, Lapayev, Zorile, and Pavlov (1979) studied the effects of angular acceleration on efficiency of control in a two-dimensional tracking mode. They found a significant decrease in efficiency of control under these conditions: an increase of 18-67% in the integral of control errors and an increase of 73-102% in duration of errors, depending on individual vestibular stability and magnitude of accelerations. The maximum decrease in performance quality was seen when both magnitude and direction of accelerations were changed. When additional motor tasks were required, quality of control decreased an average of 47%, indicating a lowering of reserve capabilities under the influence of rotation.

## **Exercise**

*Key words: sports medicine, training, fitness*

A new textbook on sports medicine (Karpman, 1980) is directed at the trainer or training program director, and focuses on intensive training and the attainment of fitness. Specific sections of interest for the space program are those dealing with the evaluation of conditioning, the use of functional tests, restoration of work capacity, medical monitoring based on age and sex, traumatism, general pathology, and acute pathological states (especially syncope).

*Key words: work physiology*

The proceedings of the 7th All-Union Conference on Work Physiology were published under the title *Work Physiology* (Medvedev, 1979). The publication contains more than 60 articles on aspects of work and exercise, including: operator performance under a variety of conditions; work scheduling and circadian rhythms; work in extreme or unusual environments; the effects of hypokinesia; use of simulators and trainers; and forecasting and evaluating fitness or performance.

## Vibration

*Key words: infrasound, motion sickness, oxygen, exercise*

An item in the Daily Soviet News Abstracts Publication (1981) reported an investigation into the effects of infrasonic sound on man. Infrasonic vibrations produced by turbulent air are mentioned as a cause of motion sickness. An infrasonic test chamber in the laboratories of the All-Union Scientific Research Institute of Rail Transport Hygiene was used to measure subjects' cardiovascular and respiratory function and higher nervous system activity. Experimental results will be used by the Institute to formulate design criteria for exposure to infrasound. Other related research and development projects involve the use of "biological stimulators" to counteract drowsiness caused by infrasound, the use of oxygen masks, and special exercises that can be performed in place by workers.

*Key words: man-machine interaction, physiological effect*

A new book on the biomechanics of man-machine environment systems (Frolov, 1981) contains a number of articles on human factors aspects of man-machine dynamics. Included are models for forecasting the physiological effect on man of vibration, and principles for designing and constructing systems of protection against vibration.

## Extreme Environments

*Key words: adaptation, stress, hypoxia*

A book by F.Z. Myerson (1981) summarizes 20 years of research on the endogenous mechanisms of adaptation to physical loads, altitude hypoxia, stressful environmental conditions, and disease. As explained in a foreword by O.G. Gazenko, Myerson bases his approach on a unique conception of individual, or phenotypic, adaptation of the organism to the environment. Environmental factors produce a functional load that elicits increased synthesis of nucleic acids and protein, forming a "structural trace" in systems responsible for adaptation to the specific stressor. Studies conducted by the author show that this takes the form of an increase in mass of membrane structures responsible for the cell's reception of controlling signals, ion transport, energy supply, and other functions. The systemic structural trace constitutes the initial adaptive reaction, serving as the basis for long-term phenotypic adaptation. The correlation between memory and adaptation is elaborated. To exemplify his thesis, the author uses the development of adaptation to hypoxia and the pathogenesis of various stress-induced lesions.

*Key words: higher functions, efficiency resistance, unusual factors*

Zagryadskiy (1979) reports findings which conflict with the general belief that higher mental and psychophysiological functions of man are most vulnerable when he is exposed to unusual factors. Data are presented to show that, under exposure to hypokinesia, altered gas environment,

isolation, intensive work, physical loads, high temperature, and other factors, these higher functions as well as operator efficiency are notable for high resistance and stability. Instead, the author concludes, it is the autonomic functions that supply them with energy, and the central nervous system, that present substantial functional changes. An analysis is made of the physiological cost of maintaining stability (resistance) of mental and physiological functions during exposure to unusual factors.

*Key words: hyperbaric medicine, gas mixtures, physiological disorders, respiratory function*

A book compiled by Chernigovskiy (1981) summarizes the current state of knowledge regarding underwater biology and medicine. Research on the hyperbaric medium and its physiological effects is highly pertinent to problems of life support within the pressurized environment of space cabins (as well as on the surface of a planet such as Venus, with its dense atmosphere). The book examines progress in overcoming "physiological barriers" to increased pressure, through the use of different gas mixtures in particular. One such barrier is the high-pressure nervous syndrome (HPNS), a condition of high excitability which occurs while breathing pressurized helium-oxygen mixtures. Various experimental means of preventing HPNS are discussed. The problem of respiratory function in a high-density gas medium is also examined, along with possible methods for improving it. A third barrier is the need to maintain temperature homeostasis in the body, which becomes increasingly more difficult as pressure is increased. Additional attention is given to the toxicity of oxygen at high pressure and to tissue saturation and desaturation by inert gases when gas pressure and composition are varied.

*Key words: hypoxia, tolerance, antihypoxic conditioning*

Katkov, Kovalenko et al. (1981) subjected healthy men to a "pulsed" mode of altitude conditioning in a pressurized chamber for 10 days. The program consisted of conditioning for 6 hours per day on the following schedule: "ascent" to 5000 m (5 m/s) and 30-min exposure; "climb" to 6500 m (5 m/s); and "descent" at 10 m/s (10 min). Before and after conditioning, tolerance to hypoxia was tested by climbing at a rate of 20 m/s through altitudes of 5000, 6000, 7000, 8000, 9000, and 10,000 m, up to maximum tolerated. Subjects spent 10 min at each altitude (including time of ascent). The following cardiorespiratory measures were recorded continuously: cardiac stroke and minute volumes, respiratory rate, heart rate, and arterial pressure. After exposure to each altitude, capillary blood was analyzed for pH,  $pO_2$ , and  $pCO_2$ . It was found that the conditioning program increased maximum altitude tolerance from 8400 m to 9500 m, and extended maximum time of exposure to increasing hypoxia from 37 min to 47 min. The antihypoxic effect of the conditioning persisted for 10 days after its completion, with better oxygenation of tissues.

*Key words: hypoxia, mental effort, EEG*

Vilenskaya (1981) studied the effect of intellectual effort on EEG patterns of individuals subjected to high-altitude hypoxia. EEGs were recorded in controls (at 760 m altitude) and on the 3rd, 10th, and 25th day of adaptation to hypoxia at 3200 m. It was found that mental tasks depress

the alpha index at both altitudes, although much more at 3200 m; depression was especially marked in the parieto-occipital region, suggesting that this region is particularly susceptible to oxygen deficiency. The number of beta waves increased during adaptation, indicating enhancement of cortical neuron excitability in hypoxia. Most subjects showed a significant increase in theta index at 3200 m; the area of greatest increase varied between the parieto-occipital and fronto-temporal. These findings indicate (1) that mental effort exacerbates the effects of oxygen deficiency at high altitudes and (2) that different areas of the brain show different susceptibility to the deficiency.

## **Psychology**

*Key words: social behavior, regulation processes*

A book by Bobneva and Shorokhova (1979) deals with psychological analysis of the mechanisms of social behavior of the personality. Chapters discuss, variously, the characteristics of normal regulation of human organizational behavior; the determination of behavior by ecological, ethnic, and genetic factors; the stages of moral development; types of mass behavior; and processes of goal-setting, self-regulation, and adaptation.

*Key words: mental self-regulation, psychomuscular training, relaxation, athletes*

Alekseyev (1981) published a book, directed primarily at athletes and those concerned with their training, in which he describes a technique of mental self-regulation he developed called psychomuscular training (PMT). The underlying purpose of PMT is to provide a mental hygienic technique as a countermeasure against the psychological effects of stress. Benefits are the ability to relax under stress, to increase alertness to required levels, and to recover strength through brief periods of autosuggested sleep-rest. Components of the autosuggestion process are: achievement of a drowsy state with relaxed, concentrated attention; relaxation of selected muscle groups in sequence; visualization and imagination of the relaxed state accompanied by verbal autosuggestion; and mental desensitization to the stressful situation. The author instructed 162 athletes in PMT techniques. A variety of physiological measurements were recorded in the course of training.

*Key words: pilot error, personality characteristics*

In order to study the correlation between pilot error and personality traits, Luk'yanova and Lobova (1981) interviewed and tested pilots who had made flight errors and trainees having difficulty in flight training. Standard personality inventories, the thematic apperception test, and the 16-factor personality questionnaire were used. It was determined that in 72% of the cases psychological traits may have been the reason for pilot unreliability. Specific adverse traits noted were: abnormalities in attention span and memory, impulsiveness, difficulties in social adaptation, emotional inadequacy, rigidity of personality, irritability, low motivation, and problems in coping with emergency situations. The author concludes that psychological tests may predict pilot error tendency.

## **Biorhythms**

*Key words: rhythm of work, biorhythms*

Work is an important endogenous factor in human physiology, affecting formation and alteration of rhythms of different physiological processes. When work becomes the source of perturbations of these rhythms, particularly over long periods, health may be significantly affected. The book *Biorhythms and Work* (Slonim, 1980) deals with the effect of rhythms of work upon work fitness and upon human biorhythms. Topics covered include various aspects of low-frequency, circadian, and high-frequency rhythms in the context of work.

*Key words: self-regulation, psychophysiological states, adaptation*

An article by Vasilevskiy (1981) discusses findings presented at a symposium on the self-regulation of functions and states. Papers addressed aspects of four subject areas: (1) neurophysiological mechanisms of somatic and visceral systems; (2) evolution and ontogenesis of self-regulation of functions and states; (3) human self-regulation of functions during adaptation; and (4) methods of adaptive biocontrol in clinical practice. New data were reported on the influence of biorhythms in mechanisms of homeostasis and adaptation. A series of papers dealt with the characteristics of cardiac rhythm under normal and pathological conditions. There was broad coverage of the results of studies dealing with directional modification of states through adaptive biocontrol.

## **Ergonomics**

*Key words: human factors, work performance, fatigue, stress, work effectiveness*

The performance of work by man is accompanied by the development of certain psychological states that affect the efficiency of work. The formation of these conditions in individuals is determined by a number of factors—some internal (personality traits, motivation, reserve capacities) and some external (type of work, workplace environment, role of man, features of the man-system interface). At the same time, each individual condition is influenced over time by one of several distinct classes of functional states, such as fatigue or excitement, apathy or depression. Leonova (1981) discusses these "human factors" and their effect on work performance, and reviews a number of theoretical attempts to devise a systematic approach to this aspect of ergonomics. An example is the activation theory, which is based on the degree of mobilization of psychophysical resources (wakefulness) that is necessary to complete an action, given both a particular subject of a certain potential and a particular task. As do all extant approaches, this theory has certain drawbacks—notably the difficulty of finding adequate psychophysiological correlations (in this case, EEG patterns) for different activation/wakefulness levels. Another area of research involves the dynamics of work capability and fatigue. Overall work effectiveness is, in this context, a function of fatigue, monotony, and psychological supersaturation, or boredom. The relationship of these and other factors to stress and adaptation is also examined.

*Key words: self-regulation, fatigue, activation level, inhibition, stress reaction*

Stryukov, Dolgolenko, and Konopkin (1981) conducted an experiment designed to isolate distinctive components of fatigue. In a preliminary discussion they stress the variability and unreliability of psychophysiological indicators of fatigue that have been used in previous studies, and the resulting difficulty in objectively assessing fatigue. They describe the physiological mechanism of fatigue as an interaction of two types of phenomena: an initial deficit arising from a decrement in some portion (the "weakest link") of the functional system, and a pattern of adaptive or compensatory alterations. The latter produce a change in the level of activation or arousal of the central nervous system—either inhibition of activity or a stress reaction. This process is governed to some extent by self-regulation of internal state and external activity. These concepts were tested experimentally by having two groups of subjects perform tiring mental work over a 4-hr period. One group was told the duration of the test; the other was led to believe that it would continue until complete exhaustion was reached. Physiological indicators measured were alpha and theta waves and pulse rate. On the basis of these measures, the first group generally showed "inhibitory" signs of fatigue (decrease in activation level toward the end of the test), while the second group demonstrated "stressful" signs (increase in activation as a result of hypercompensatory reaction strategy).

## Pharmacology

*Key words: immunopharmacology, research review*

Kovalev (1981) presents a comprehensive review of recent research in the field of immunopharmacology. Such central problems as the fate of exogenous chemical compounds in the body, mechanisms involved in the action of chemical compounds on the immune system, immunotoxicology, the mechanisms of antiallergic drugs, immune response to drugs, and antibody formation in response to physiologically active drugs are discussed at length. The main thrusts of the Soviet program of research in immunopharmacology are described.

*Key words: eleutherococcus, adaptation, work performance, sailors*

Soviet studies have shown that eleutherococcus (ginseng) extract increases human mental and physical performance capacity, improves thermal resistance, and accelerates adaptation to unusual environmental conditions. Berdyshev (1981) reports a study in which the preparation was used to accelerate the process of adaptation and the maintenance of stable performance capacity of sailors in the tropics. Earlier studies had established the optimally effective daily dose as 4 ml. Most sailors received this dosage; 15% received 2 ml or 8 ml. Compared to controls who did not take eleutherococcus, those who did (no matter the dosage) generally showed a noticeable improvement in functional condition before and after watch duty. They demonstrated improved performance capacity indicators, higher rate and accuracy of command/task response, and fewer errors; they also showed a less pronounced decrease in certain measures of strength, and a better cardiovascular response to physical load. The positive effect of the preparation was still in evidence 8-9 hrs after ingestion. It was found to be most effective during intensive work under unfavorable environmental conditions, and during the acute phase of adaptation.

## Nutrition

*Key words: nutritional status, hypokinesia, mental work, balanced diet*

Popov and coworkers (1979) investigated the nutritional status of 2 individuals who spent 96 days under hypokinetic conditions with no exercise, but while performing a large amount of operator work daily. The subjects received a specially prepared diet of 3000 kcal/day, balanced with regard to protein, fat, and carbohydrate content. On this regimen they demonstrated a negative nitrogen balance and creatinuria, a decrease in blood amino acid content, decreased excretion of sodium and chlorides, higher blood sugar levels, and substantial weight loss. The authors attribute these findings to the change in diet as well as to muscle catabolism due to hypokinesia. They conclude that under hypokinetic conditions the diet should be balanced with regard to energy expenditure; intake of carbohydrates and fats should be restricted; and adequate amounts of proteins, minerals, and vitamins must be provided.

*Key words: dehydrated foods, storage, irradiation, hypokinesia, amino acid metabolism*

Meals consumed on spaceflights into the foreseeable future will come primarily from supplies of dehydrated foods. Thus they will have been stored for long periods and exposed to large amounts of ionizing radiation. Bychkov, Borodulina, and Vlasova (1981) explored the effects of these factors on the biological value of protein contained in such food, using amino acid concentrations in blood and urine as an indicator of adequacy of protein intake. Over periods of 60-120 days, subjects ate dehydrated foods that were either freshly prepared or stored for 1 or 2 yrs; some of the stored foods were also exposed to proton radiation of 12,000 and 24,000 rads, respectively. Other groups were subjected to 120-day clinostatic hypokinesia and were fed a normal, well-balanced diet; two of the groups also received pharmacological agents to prevent certain metabolic changes. It was found that storage and irradiation of the dehydrated foods did not appreciably affect the biological value of their proteins. Hypokinesia alone, with normal diet, produced an increase in total free amino acids in blood serum and urine.

## Crewmember Selection and Training

*Key words: work fitness, evaluation principles*

Methodological principles are needed for evaluating the fitness of participants in space missions. Yendal'tsev (1979) has set forth principles, for use in evaluating the fitness of industrial specialists, which are of general applicability. His first principle is to determine the physiological reserves of the body, stressing dynamics of change in parameters. The second principle consists of examining the dynamics of correlation between functional state of the body and efficiency of work. This correlation demonstrates the physiological "cost" of exertion. The third principle is to consider changes in the structure of work activity or its elements, and the specific behavioral reactions of workers to the work activity and environment.

*Key words: rheograms, regional hemodynamics, time of day, orthostatic test*

Rheography was used to assess hemodynamics of the large hemispheres of the brain, vertebral-basilar system, lungs, and legs of 60 cosmonauts (Vasil'yeva, Yarullin, & Zhuyko, 1981). Studies were made twice a day, under basal metabolic conditions in the morning and just before the orthostatic tests later in the day, as part of the procedure for certifying the cosmonauts for flight. Two age groups were represented: 30-37 and 38-47 yrs old. Comparison of hemodynamic parameters recorded in the two time frames and the two age groups revealed significant differences in the effects of certain factors (activity, diet, and particularly psychoemotional tension in anticipation of orthostatic test) on vasomotor regulation. The older cosmonauts showed greater resistance of cerebral and pulmonary vascular systems to those effects. The primary conclusion regards the importance of examining regional rheograms under basal metabolic conditions on the morning of functional tests.

*Key words: ischemic heart disease, psychological stress test, exercise stress test*

Kvantaliani, Kavtaradze, and Mamaladze (1981) evaluated the responses of patients with ischemic heart disease to psychological stress testing and to a combination of psychological and exercise (bicycle ergometer) stress tests. Subjects were 70 males aged 30 to 60 who had either atherosclerosis with angina, postinfarct cardiosclerosis with angina, or cardiac pain syndrome without lesions of the coronary vessels. Results showed that psychological stress testing is sensitive to changes in heart rate and elevated systolic pressure, and is particularly useful in detecting occult arrhythmias in patients with high physical tolerance. The combination of tests can be used for studying ectopic cardiac activity in patients with ischemic heart disease, and for detecting those who are particularly susceptible to psychological stress.

*Key words: EEG, psychophysiological measures, personality traits*

In work characterized by high degrees of psychological-emotional strain, occupational selection can include measures of bioelectrical activity of candidates to assess the functional state of the brain, higher nervous activity, and personality qualities. Lobzin and Zinchenko (1981) used a combination of EEG and psychophysiological examination to reveal unfavorable symptom complexes in prospective operators. Psychophysiological techniques used permitted study of properties of memory, perception, thinking, attention, and the psychomotor system. Psychological features identified included extroversion, introversion, and neuroticism. Preferred combinations of these measures were identified. Unfavorable symptom complexes were: (1) the combination of desynchronous (flat) EEG with low alpha values with eyes open and closed, weak nervous processes, and dominance of excitation, intro/extroversion, and neuroticism of the personality; and (2) hypersynchronous EEG with high alpha-index with open eyes, imbalance of the nervous processes, and dominance of inert inhibition, introversion, and potential neuroticism of the personality.



*Key words: cosmonaut training, physical, psychological*

An article in the *Soviet Military Review* (Barchukov, 1981) presents an interview with A.A. Leonov, Deputy Head of the Cosmonaut Training Center, regarding the overall training of cosmonauts. Leonov discusses the highly varied program of ground-based training, including individually tailored exercises and sports activity. The facilities available at Star City are described. Apparatus and techniques for providing vestibular training ("hydroweightlessness" pools, "flying laboratory," etc.) and flight training (free-fall jumps) were reviewed. Psychological training includes group games and joint training to develop cooperativeness and compatibility. Cosmonaut trainees are subjected to heat chamber testing of reserve strength capacities, and they spend 10-15 days alone in an isolation chamber to test their psychological resistance to prolonged confinement. In addition, the provisions for inflight physical training are reviewed, including the use of expander devices, treadmill, and veloergometer, and the "Chibis" vacuum suit and "Penguin" constant-loading suit. Leonov cites improvements in cosmonaut adaptation to spaceflight conditions, maintenance of conditioning, and readaptation to gravity as evidence of the effectiveness of these programs.

## **Simulation Studies**

*Key words: simulator, trainer, visual situation simulation*

One category of model is the simulating device, which can be applied in the aerospace field either as a trainer or as a developmental simulator for research on aspects of flight and aircraft control. The use of simulators and trainers in aviation has increased greatly over the last decade because of the significant advantages they offer over actual flying: lower cost, time, and personnel/facilities requirements; greater safety, event reproducibility, and overall effectiveness. The same benefits are even more clearly apparent in their use in space programs. Babenko (1978) published a book dealing with theoretical validation and technical execution of one of the most important subsystems of the modern simulating device, the simulator of the visual situation (SVS). The primary focus is on SVS of take-off and landing in a complex aircraft trainer, with optical-mechanical, cinematographic, TV, and computer graphic imaging techniques.

## **Space Biology**

### **Cardiovascular System**

*Key words: cardiac output, direct measurement, indirect measurement, dogs*

Indirect methods of measuring cardiac output have the advantage of being repeatable and atraumatic. However, the objection has sometimes been raised that they are not accurate enough and are not adequate for use in rapidly changing hemodynamic situations. Doroshev and colleagues (1981) compared direct and indirect methods of measurement of cardiac output in dogs before and after drug test. The two direct methods were the Fick method and electromagnetic flowmetry; the

indirect methods were rheography (RM) and tachooscillography (TM). No significant differences were found between readings obtained at rest by TM, RM, and the Fick method, or between readings obtained by the Fick and TM methods after imposition of pharmacologic load. All readings of cardiac output increased substantially after the drug test, but the highest correlation was seen between the flowmetric and RM methods. Because these two methods permit calculation of cardiac output for virtually every cardiac contraction, they are most useful when hemodynamics undergo rapid changes. The Fick method and TM, on the other hand, are more suitable for observing processes developing over 30-40 sec.

*Key words: central hemodynamics, emotional stress, pressor response, dogs*

Lissova, Beregovskiy, and Kochetenko (1981) measured parameters of central hemodynamics in dogs in the presence of negative emotional responses such as anger and fury. The contribution of cardiac and vascular parameters in the pressor response to such stress was determined, and the nature of homeostatic regulatory responses directed at reducing arterial pressure was clarified. Measurements were taken of arterial and central venous pressure, rate of blood flow, minute volume, and heart rate. From these, total peripheral resistance and the cardiac pumping function coefficient were calculated. The effects on central hemodynamics of epinephrine, reduction of total blood volume, and physical stress were then recorded. It was found that the first two factors served to compensate pressor reactions, while the third had no pressor effect but did affect total peripheral resistance.

*Key words: immobilization stress, renin activity, catecholamines, arterial pressure, rats*

Kvetnyanskiy, Belova, and coworkers (1981) studied plasma renin activity and its relationship to the level of catecholamines and the dynamics of arterial pressure in August and Wistar rats under immobilization-induced emotional stress. Blood samples were taken before and during (after 20 and 120 min) immobilization; arterial pressure was measured after 1 and 2 hrs of immobilization. Results showed that renin activity was elevated in both lines of rats, but the relationship of renin activity to changes in arterial pressure and plasma catecholamines differed. In terms of cardiovascular functions, Wistar rats appeared to be more resistant to emotional stress. Renin activity in these rats was higher, with marked changes in arterial pressure.

## Metabolism

*Key words: acute stress, cardiovascular reactions, autonomic nervous system, metabolic changes, rabbits*

Gorbunova and associates (1981) conducted comprehensive physiological-cytochemical studies to determine the effect of acute experimental emotional stress (due to electrical stimulation of the hypothalamus and skin) in immobilized chinchilla rabbits. In particular their objective was to isolate individual peculiarities of the dynamics of cardiovascular reactions of rabbits under such

conditions, and to determine the degree of involvement of certain cellular formations of the autonomic nervous system in these reactions. On the basis of changes in arterial pressure under stress, three groups of animals were isolated: stable (no change), adaptive (nonfatal changes), and pre-disposed to the development of stress (death occurring). In animals of the third group, there were indications of dissimilar metabolic shifts in various extramural ganglia of the autonomic nervous system and the sympathetic network. The most pronounced changes occur in the nodal ganglion of the vagus nerve, where catabolic changes predominate over anabolic. In the stellate ganglion and sympathetic circuit, anabolic processes develop. The superior cervical sympathetic node occupies an intermediate position on this metabolic scale.

*Key words: hyperoxia, lipid metabolism, oxidation, rats*

Gabilov and Karagezyan (1981) investigated the effect of hyperoxia on lipid metabolism in various tissues. Rats were subjected to oxygen at 5 atm until the onset of convulsions or the terminal stage of intoxication. Lipid oxidation was determined in the brain, liver, heart, spleen, skeletal muscle, and blood. Oxide formation was determined from accumulation of malonic dialdehyde. Lipid oxidation was found in all tissues studied, particularly in cerebral tissue. In the convulsive and terminal stages, shifts were most marked in the myocardium, blood, skeletal muscle, brain kidneys, and liver, in that order. During the post-hyperoxic period, lipid oxidation was resolved most rapidly in the brain. The authors conclude that the index of normalization of lipid metabolism following hyperoxia can be used as an indicator of vitality. They suggest that the mechanism of normalization is a powerful antioxidant system both enzymatic and nonenzymatic in nature.

*Key words: thermophysiology, temperature adaptation, homoiotherms, poikilotherms*

A book presenting the results of experimental research dealing with metabolic compensation on the tissular and organismic levels has been published (Ivanov & Slonim, 1980). A new conception of the gradient of temperature functions of different systems ( $Q_{10}$  gradient) is outlined, and the possibility of using it to explain ecological and physiological relationships in poikilothermic and homoiothermic organisms is discussed. Data are also submitted on changes in temperature dependence of tissular metabolism in relation to temperature adaptation and brief changes in ambient temperature. Subject organisms include mice, bats, voles, frogs, fish, and various reptiles.

*Key words: gamma-hydroxybutyric acid, sympathoadrenal system, rats*

Meerson and associates (1981) tested the hypothesis that activation of the gamma-aminobutyric acid (GABA) system and the resulting secretion of gamma-hydroxybutyric acid (GHBA) have a protective effect in stress by limiting excitation of the sympathoadrenal system. GHBA was administered to rats before and after 3 hrs of pain-induced stress. After the animals had been sacrificed, changes in catecholamines were found in the heart, small intestine, hypothalamus, and other organs, together with changes in the synthesis and neuronal uptake of norepinephrine in the myocardium. It was found that administration of GHBA prevented stress impairment of the sympathoadrenal system and the development of gastric ulcers.

## Hypokinesia

*Key words: circadian rhythm, mitotic activity, DNA synthesis, rats*

Romanov and coworkers (1979) studied circadian rhythms involved in DNA synthesis, the duration of the premitotic cycle, and mitotic rhythms in the tissues of hypokinetic rats. Movement was restricted for 34 days. Animals were sacrificed at hours 10, 16, 22, and 24 of the final day, after receiving an injection of <sup>3</sup>H-thymidine 1 hr before sacrifice. Mitotic index and radioactive index were determined for parenchymal and stromal liver cells; epithelial mitotic activity and DNA synthesis were determined for the small intestine. Min/max differences over 24 hrs showed a marked decrease in the mitotic and DNA-synthesizing activity of liver cells; the pattern of circadian activity changed only slightly. It was concluded that 34 days of hypokinesia caused a marked drop in DNA-synthesis and mitotic activity.

## Vestibular System

*Key words: control processes, vestibular studies, historical review*

A monograph published in 1978 by W. Precht (1981) is concerned with the patterns involved in information processing and control processes in the vestibular system. Initial sections present an historical review of research in this field, in which the author points out the following stages of development: (1) discovery of the function of the vestibular apparatus and the description of reflex and behavioral reactions of vestibular origin; (2) mechanical vibration of the cupula in the semicircular canal and the development of mathematical models of the cupula; (3) early experiments to record the electrical activity of the afferent branches of the isolated labyrinth when acted upon by acceleration; and (4) the initial studies on neuron activity in the vestibular nuclei and other neural centers. Four chapters are devoted to experimental aspects of vestibular studies and their results.

*Key words: internal/external analyzers, sensory control*

A monograph by Raytsev (1981) correlates data from the literature with his own electrophysiological investigations into the functional organization of sections of the internal analyzers and the mechanisms of interaction of visceral afferent signals with sensory streams entering the nervous system from somatic, vestibular, and visual receptors. Current findings on the participation of the hypothalamolimbic structures of the brain in the control of sensory processes and in the mechanisms of the interaction of intero- and exteroceptive signaling are reported. The book examines the significance of visceral signaling in the formation and realization of certain forms of emotional reactions and purposeful behavior, as well as in disturbances of the emotional sphere under conditions of visceral pathology. The bibliography, with 450 titles, provides a comprehensive listing of literature on the subject.

## Radiation

*Key words: ionizing radiation, chronic exposure, albumin, cholesterol, dogs*

Chronic exposure to low-level ionizing radiation could lead to discrete functional disorders that are not easily detected. In order to demonstrate latent changes in protein metabolism under such conditions, Akhunov (1981) exposed dogs to 190, 360, and 560 rad over a period of 3 yrs, using bloodletting at the end of the experimental period to evoke changes in blood serum total protein and protein fractions, as well as cholesterol. A control group consisted of nonirradiated dogs. The biochemical parameters were measured before the load, and then 1, 2, 5, 7, 12, 20, and 42 days after. Through the 7th day, the three experimental groups and the control group showed the same reaction to bloodletting, with an initial decrease in protein and cholesterol content. Thereafter, the recovery process became different for experimental and control groups. Albumin levels dropped again in irradiated dogs and subsequently recovered more slowly, while control dogs exhibited a steady normalization. Normalization of cholesterol level was the same in all groups except in dogs that had received the highest dose (560 rad). In that group, hypocholesterolemia persisted throughout the observation period. The author attributes these instances of slower recovery to depressed synthesis of albumins and cholesterol in the livers of irradiated dogs.

*Key words: bone marrow, recovery processes, mice*

Postradiation recovery of bone marrow of mice after 5 days of total and partial irradiation was studied by Pozharisskaya and Sokolova (1981). Specifically, changes in the number of myelocaryocytes of different maturity, the proliferative activity of homopoietic cells, and the number of cells capable of DNA synthesis were determined. Early activation of recovery processes in activated sections of the bone marrow was noted by the 5th day; the recovery process is marked by an increase in the number of nucleus-containing components and young cells capable of proliferation.

*Key words: radioprotective agents, biochemical bases, molecular mechanisms*

Radioprotective agents were originally devised for protection against minimal lethal doses of ionizing radiation. It is now apparent that it ought to be possible to provide protection against much larger doses of penetrating radiation. For this reason, research on the biochemical bases of agents that modify radiation effects is increasing rapidly. A book by Romantsev and coworkers (1980) presents an original conception of a complex biochemical mechanism of action of radioprotective agents on the molecular level, and summarizes the state of research in this area. Special attention is given to processes of temporary inhibition of replicative processes and stimulation of DNA repair processes. Chapters are devoted to the effects of radioprotective and radiosensitizing agents on DNA metabolism, RNA biosynthesis, processes of DNA replication and repair, protein synthesis in animals, and energetic processes in the cell. Much attention is given to analysis of molecular mechanisms of action of these agents, including the different phases of their biological activity.

*Key words: radioprotective agents, endogenous bioresistance background*

A book by Goncharenko and Kudryashov (1981) examines a number of prevailing conceptions of the biophysical and biochemical mechanisms of the radioprotective effect, such as those expressed as "biochemical shock," "complex biochemical mechanism," and "endogenous thiols." Included among these is the authors' own hypothesis of "endogenous radioresistance background" and the routes of its expression (see figure). The large number of hypotheses that have arisen is explained on the basis of the large number of methods of expression of the biochemical prophylactic effect. The search for the "ideal radioprotective agent" is outlined, with emphasis on the modification of drugs in order to enhance and prolong their radioprotective effect and to eliminate side effects.

*Key words: laser irradiation, plasma phosphatases, rats*

Serykh and coworkers (1980) studied the effect of multiple laser irradiation on the activity of alkaline and acid phosphatases of blood plasma in 80 rats. The activity of acid phosphatase of the blood plasma was found to be less subject to change than was the activity of alkaline phosphatase, with radiation dosage level affecting the level of activity of the enzymes. The animals did not show variation of blood plasma phosphatase activity after 8-10 exposures of laser irradiation. The hormone balance in the organism also significantly affects the activity of the alkaline phosphatase. The level of acid and alkaline phosphatase activity is shown to be useful as an indicator of the functional state of the organism and of resulting pathological deviations.

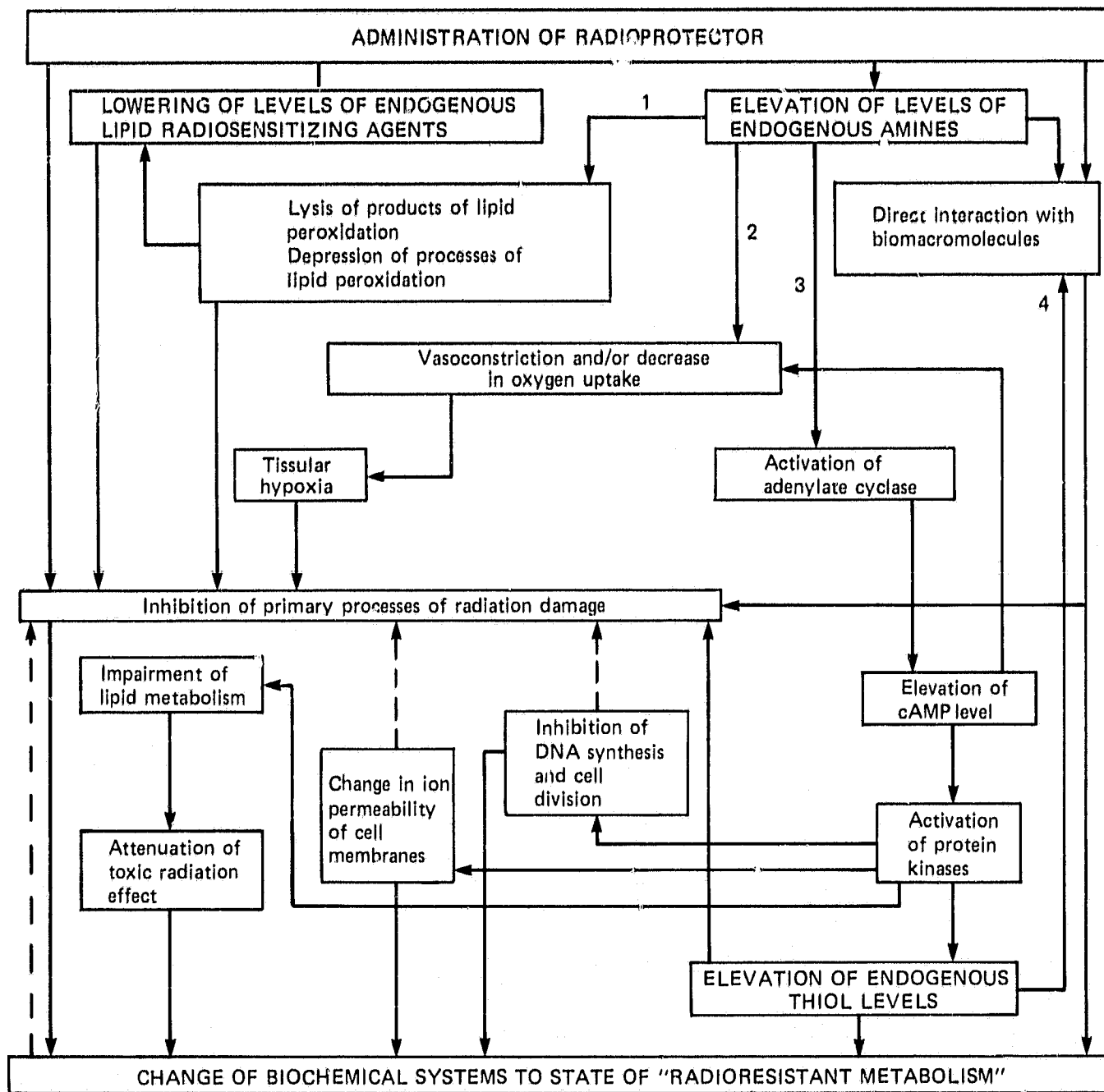
*Key words: nonionizing electromagnetic radiation, microwaves, quantitative radiobiology*

Spacecraft onboard instruments and equipment emit nonionizing electromagnetic radiation (EMR) in a variety of frequency ranges, and sometimes at a high level of output. A book by Antipov, Davydov, and Tikhonchuk (1981) in the *Problems of Space Biology* series summarizes and analyzes existing experimental and clinical data on the biological and biophysical effects of EMR. The authors also present their own experimental findings on the effects of EMR in the microwave range. Particular attention is given to the environmental combination of EMR with other spaceflight factors, including ionizing radiation. Analysis is carried out from the standpoint of quantitative radiobiology, using the concept of "energy interaction" between EMR and biological objects. Studies include the correlations between biological effects and radiation density, time of exposure, and type of biological object on different levels of organization (cellular, systemic, and organismic) in a variety of animal species.

*Key words: superhigh-frequency electromagnetic field, immune reaction, rabbit testes*

Research has shown that a superhigh-frequency electromagnetic field (SHF EMF) of nonthermal intensity elicits aspermatogenesis and development of lymphoid infiltrates in the interstitial tissues of testes. It is thought that this damage is due to the development of an autoimmune process made possible by lesion of the hematotesticular barrier (HTB). Grigor'yev, Ogurtsov, and Zubhitskiy

# Routes of Expression of "Endogenous Radioresistance Background"



KEY: (1) effect on processes of lipid oxidation  
(2) hypoxic effect  
(3) effect on system of cellular regulation  
(4) interaction with biomacromolecules

(1981) investigated this hypothesis, using immunomorphological and histological methods and electron microscopy to detect changes in the testes of rats exposed to 6 min of local SHF EMF. Experimental animals were divided into three groups on the basis of their reactions: one group developed only mild reactive changes in the testes, with spermatogenesis returning to normal in 5-6 days; a second group presented microscopic hemorrhages and atrophy of spermatogenic epithelium in certain areas; the third group revealed severe dystrophic changes, with the appearance of lymphoid infiltrates in the seminiferous tubules and other tissues. Evidence was found that both the humoral (antibodies) and cellular (sensitized lymphocytes) immunological mechanisms have a deleterious effect on the testes in the presence of impaired HTB permeability resulting from SHF EMF exposure.

## **Magnetic Fields**

*Key words: tumor growth, partial oxygen pressure, radiosensitivity, rats*

Lyu and Kauashev (1981) investigated the effect of exposure to a permanent magnetic field on variation of partial oxygen pressure in tumors of rats. In several types of tumors studied, partial oxygen pressure increased under exposure to the magnetic field and decreased when it was removed. The growth rate of tumors was found to decrease after exposure to a combination of magnetic field and radiation. Periodic 1-hr magnetic exposure preceding irradiation caused an erratic growth of tumors, while 5- and 30-min exposure to magnetic field alone had no effect on tumor growth.

*Key words: variable magnetic field, sympathoadrenal system activity, rats*

The activity of all parts of the sympathoadrenal system (SAS) increases under the influence of a variable magnetic field (VMF) of sufficient intensity and duration. Sakharova, Ryzhov, and Udintsev (1981) investigated alterations in the relationship between the SAS and the central nervous system, the glucocorticoid function of the adrenals, and catecholamine (CA) reserves in response to a VMF. Rats were placed in a magnetic field of 200 Oe, 5 H<sub>z</sub> for 1 day after administration of phenobarbital (to exclude the CNS), rausedyl (to mobilize CA reserves), or dexasone (to induce atrophy of the adrenal cortex). There was no reaction of the SAS to VMF in experiments in which phenobarbital and rausedyl were administered; whereas with dexasone all parts of the SAS except the mediator were involved in the reaction. The authors believe that findings with phenobarbital and dexasone indicate a neuroreflex mechanism in the reaction of the SAS to VMF. The experiments with rausedyl demonstrated that the CA reserve levels in organs are important in the formation and degree of SAS reaction to the stressor; hemodynamic and morphological changes induced by the magnetic field in cellular elements of organs appeared to be related to mobilization of reserve CA in response to the field.

*Key words: constant magnetic field, magnetobiology, research review*

Functional disturbances of the nervous and cardiovascular systems and tendency toward hypotension seen among individuals who are chronically exposed to constant magnetic fields (CMF)



could indirectly indicate changes in the functional activity of the endocrine system. The reversibility of these changes under brief exposure implies that regulatory mechanisms are involved. A review article by Zagorskaya (1981) presents information about the phasic pattern of the hypophyseal-adrenal reaction to CMF and its effects on the sympathoadrenal system and thyroid. Many publications are cited demonstrating the high sensitivity of testes to CMF. The paper discusses potential therapeutic applications of the CMF, with emphasis on the fact that most available morphological data need biochemical support.

## Extreme Environments

*Key words: hyperbaria, helium-oxygen gas mixture, oxygen demand, hypothermia, rabbits*

Using experimental findings on oxygen demand in rabbits within a narrow temperature range, Lobanov (1981) attempted to determine the neutral temperature and the lower lethal temperature in a hyperbaric helium-oxygen atmosphere. Two series of experiments were conducted. In the first, the animals were kept in a hyperbaric helium-oxygen atmosphere for periods of 5, 9, and 20 days; temperature was maintained at 297-302° K and the animals were free-running. Conditions for the second series were the same except that mobility was restricted and the temperature was maintained at 293° K. Results showed a linear correlation between oxygen demand and temperature. The neutral temperature zone was established at 302° K; at a temperature of about 294° K, metabolism was unable to compensate for loss of body heat and all subjects died from hypothermia. It is concluded that hyperbaric conditions increase respiratory heat loss and reduce heat exchange from the skin of warm-blooded animals; thus, additional heat and humidity are required in the mixture being breathed.

## Biorhythms

*Key words: adaptogenesis, circadian rhythms, rats*

A collection of articles on chronobiology (Genin, 1981) addresses current questions of adaptogenesis in living systems, as regards their time organization and dynamics of circadian rhythms. The first section of the book deals with the analysis of theoretical issues of biorhythmology and the results of human biorhythm studies. A second section is directed at animal biorhythms. All studies in the latter section were carried out with male Wistar rats, and under the same conditions of illumination, temperature, and feeding. A variety of methods were employed to determine circadian rhythms of general physiological parameters (motor activity, body temperature, gas exchange), the functional state of the hypothalamo-pituitary-adrenal system, rhythms of cell reproduction, and activity of certain elements of nucleic and fluid metabolism. The overall objective of this battery of experiments was to identify patterns of change in the main features of circadian processes—their level, amplitude, acrophase positions, and wave shapes.

## Pharmacology

*Key words: neurotropic drugs, baroreceptor reflexes, cats*

Tsyrlin and Yekimov (1980) investigated the effect of several neurotropic drugs on variation of the baroreceptor reflexes that occur upon stimulation of the hypothalamic structures in cats. Diazepam, sodium etaminal, and oxyldine reduced the vascular response to such stimulation through direct inhibition of processes of descending activity of segmentary vasomotor neurons and through suppression of hypothalamic modulation of baroreceptor reflexes. The drugs catapresan and dopegyt were found to have no effect on the hypothalamic modulation of the baroreceptors.

*Key words: cystamine, mexamine, radioprotective effect, E. coli, rats*

Belyakova, Kravetskaya, and Krutyakov (1981) investigated the effect of 2-mercaptoethylamine (cystamine) and 5-methoxytryptamine (mexamine) on the activity of DNA-polmerase I and exonuclease III from *E. coli* and DNA-polymerases  $\alpha$  and  $\beta$ , endonuclease I, and 3'-endonuclease from the chromatin of the rat liver. Their objective was to compare the effect of protectors on the activity of purified repair enzymes and corresponding chromatin activity, nuclei, and cells. It was found that a quantity of only 20 millimoles of mexamine appreciably reduces the activity of DNA-polymerase I and DNA-polymerase  $\alpha$ . DNA replication in the cell is retarded by the protectors, which diminishes reproductive death and increases the length of repair. The action of the protectors is modulated by the quality of the DNA matrix, which is strongest in DNA-polymerase  $\beta$ . The protectors do not affect the action of exonucleases in nonirradiated DNA, and have no effect on the activity of chromatin endonuclease I or on nuclease degradation of DNA newly synthesized in irradiated chromatin in vitro. Their effect on the activity of repair enzymes depends on the quality of the DNA substrate or DNA matrix, whether in native or irradiated DNA, deproteinized DNA, or DNA in the chromatin and nuclei. Moderation of nuclease degradation enhances the effectiveness of repair.

*Key words: cystamine, mexamine, radioprotective effect, Crepis capillaris*

The basic mechanism of action of many radioprotective agents is uncertain. In order to clarify the biophysics of the radioprotective effect of cystamine and mexamine on DNA, Sidorov (1981) treated cells of *Crepis capillaris* with a solution of these drugs for 3 hrs and then irradiated them with gamma rays at a dosage of 200 rads. A study was then made of the degree of radioprotection offered by the cystamine and mexamine with and without the addition of the DNA inhibitor 5-aminouracil by evaluating chromosomal aberrations over two sequential cell divisions. In diploid cells, chromosomal and chromatid aberrations were held at control levels with the radioprotectors alone; but the addition of 5-aminouracil caused a sharp increase in the number of aberrations. Findings for tetraploid cells were similar. Thus, the radioprotective effect of cystamine and mexamine was seen mainly in regard to chromosomal and chromatid aberrations in both types of cells. The effect of 5-aminouracil in nullifying the effect of the radioprotective agents indicates that their action is not associated with reducing primary damage in DNA, but rather with an inhibitory effect on this damage in chromosome aberration.

## Microbiology

*Key words: membrane biophysics, structure, electrical characteristics*

The biophysics of membranes is an important element of current research in biological physics. Such basic processes as the utilization of energy released from tissue respiration, photosynthesis, and the active transport of ions are related to the function of membranes. A new book on this subject (Blyumenfel'd, 1981) includes a large number of articles on different aspects of membrane biophysics. The two main problems addressed are the structure of membranes and electrical characteristics of natural and artificial membranes. Prominent attention is given to the study of phase changes in model and biological membranes, to characteristics of the electrolyte layers near membrane boundaries, and to electric breakdown of bilayered lipid membranes.

## Plant Research

*Key words: radioresistance, hybrid forms, genotype, heterosis*

The problem of radioresistance of organisms on different levels of organization and individual differences in resistance of tissues and cells is a focal one in modern radiobiology. Turbin, Volodin, and Gordey (1977) have made substantial progress toward identifying the mechanisms of radioresistance in plants with their research on the relationship between radioresistance and genetic status. They have used genetic technology to experimentally produce homozygotic and heterozygotic, heterotic and nonheterotic, and other related hybrids of the same plant specimen for comparison of radioresistance characteristics. The work reported here represents research on four related fronts. The first objective was to study reactions of hybrids and their parents to presowing irradiation of seeds over the course of a reproductive cycle. The second objective was to compare the reactions of homozygous and heterozygous plants to radiation. Third, they determined the role of hybrid and heterotic states of the genotype in postradiation repair processes. Fourth, they studied the effect of successive irradiation of several plant generations on radioresistance and mutability. The data presented on cytogenetic mechanisms of radioresistance in heterotic forms represent an original discovery.

## Life Sciences Technology

### Bioinstrumentation

*Key words: radiobiology, gamma devices, modeling*

A book by Gladilkin et al. (1981) describes a number of gamma devices developed primarily for carrying out ground-based radiobiological studies to ensure radiation safety in space missions. The *Lyustra* gamma device is used for modeling the chronic effect of galactic radiation on large animals, while the *Kobal't* device models the acute effects of solar flare emanations. The *Yenot-1* and *Yenot-2* gamma devices are intended to model chronic and acute radiation effects on small

animals over a wide range of dosages. The *Svet* device is used to determine the coefficients of relative biological effectiveness of heavy charged particles. The *Start* device is used for ground simulation of various inflight radiobiological experiments. The *Integral* and *OU-3* are small, lightweight devices developed for both ground-based and inflight radiobiological experimentation; the latter device was flown aboard Kosmos 690. Problems and techniques involved in the design and development of these experimental devices are discussed.

## Closed Life Support

*Key words: bacterial aerosol, ionized air, particle size*

One of the chief mechanisms of transmission of bacteria and other automicroflora of people in a pressurized enclosure such as a spacecraft cabin is in aerosol particles. The density and size of particles comprising such a bacterial aerosol is determined by a number of factors, including their electrical charge. The constant presence of ionizing radiation in space, by causing a 20- to 100-fold increase in light ion concentration of the spacecraft atmosphere, alters the charge and thus the overall makeup of the bacterial aerosol. Zaloguyev, Anisimov, and coworkers (1981) artificially ionized the air of a pressure chamber with a microclimate similar to that of a spacecraft cabin in order to examine the effect on the bacterial aerosol produced by the chamber's inhabitants. They found that with normal (near-Earth) air ionization levels there was a prevalence of microorganisms in aerosol fractions with particles 7.2–11.6  $\mu\text{m}$  and 0.6–2.3  $\mu\text{m}$  in diameter. Ionization of the air caused a large decrease in the number of microorganisms in particles of the larger size and of an intermediate size (4.5–5.3  $\mu\text{m}$ ). There was little change in the smaller-sized aerosol fraction. This decrease in overall bacterial contamination under higher levels of ionization was seen in all forms of microflora tested except one (sporulated Gram-positive bacilli).

*Key words: regenerated water, organic carbon assay, direct method*

Water produced by a spacecraft's life support system may be regenerated from moisture-containing human waste (atmospheric moisture condensate, urine, and housekeeping wastewater) and equipment waste fluids. Water reclaimed from these sources contains biologically active organic compounds of toxicological and hygienic significance. Standard (indirect) methods for assaying total organic substances in water are inaccurate and are nonrepeatable. Koloskova, Pak, and Chizhov (1981) report their use of a method based on infrared spectroscopy to directly assay total, organic, and inorganic carbon content of reclaimed potable water. The two-channel analyzer relies on combustion of carbon to  $\text{CO}_2$  to measure either total or inorganic carbon; organic carbon is calculated as the difference between these two. Water reclaimed from atmospheric moisture aboard Salyut 4, 5, and 6 and returned to Earth, as well as reclaimed water obtained from urine, was analyzed by this means. Parallel assays were made with a standard indirect method (determining chemical oxygen uptake). The direct assay was shown to be faster and more accurate, in addition to providing a more complete assay of impurities.

*Key words: plant condition, closed ecosystem, "indicator" microorganisms*

Kovrov and Tirranen (1981) attempted to identify "indicator groups" of microorganisms whose concentration in microbiocenoses of plants and nutrient solutions can be used as an index of the condition of plants in a closed ecosystem. Aerobic and anaerobic bacteria of the *E. coli*, *Proteus*, and *Lactobacillus* groups were selected as indicators because they flourish under conditions of environmental contamination. Fungi and yeast were included because they could act as human and plant pathogens. Experimentally derived maximum concentrations of the selected microorganisms for healthy condition of plants are presented. Some of the indexes are relative: for example, the ratio of number of *Caulobacter* to ammonia producers should be  $\geq 1$  for good condition of plants. The authors propose that use of these indicators makes it possible to indirectly evaluate the condition of plants in any closed ecosystem. Because the number of indicator microorganisms increased before worsening plant condition could be detected visually, the technique is also predictive.

*Key words: plant wastes, microbial degradation, efficiency*

In closed life support systems based on the recycling of matter there must be a means of converting higher plant wastes into a form that can be assimilated by plants. Chernovich, Sidorova, and Mal'tseva (1981) investigated the effectiveness of microbiological mineralization of organic matter in wheat chaff and vegetable tops. A microbial cenosis was formed consisting of fungi and other soil microorganisms capable of decomposing plant cellulose. Experiments were conducted in fermenters at 22° C and 36° C for 5, 10, and 20 days. At the end of the experiments measurements were made of dry mass, organic matter in sediment, and cellulose content in the dissolved portion and sediment. The amounts of CO<sub>2</sub> and NH<sub>3</sub> discharged during decomposition were also measured. It was found that the degradation of vegetable wastes was more complete than that of wheat chaff. In both cases, the efficiency of the process increased with time and temperature.

*Key words: thermal control, systems analysis, mathematical modeling*

The book *Thermal Conditions in Spacecraft*, by Malozemov (1980), takes a systems approach to the analysis of characteristics of a spacecraft's thermal control system. The primary organizing principle is the concept of man as the main element of such a system, which should be responsive to the dynamics of change in his thermal status, which includes the state of his preset adaptive mechanisms. The author proposes that the thermal control system, in conjunction with an appropriate conditioning program and devices for measuring and forecasting the physiological status of crewmembers, could assume some of the functions of an inflight training device. One chapter presents a general treatment of the provision of an adequate thermal environment, including a new system classification. Another chapter is concerned with the analysis of internal and external heat loads. Others deal with the mathematical modeling of elements and subsystems, and problems pertaining to choice of system design parameters.

## SPACEFLIGHT RESULTS

### Space Medicine and Physiology

#### Mission Reviews

*Key words: Interkosmos program, biomedical research, cardiovascular system, psychology, radiation protection*

An article in *Pravda* (Burnazyan, 1981) surveys biomedical research carried out in space aboard Cosmos biosatellites and, in particular, by cosmonauts of the Interkosmos program aboard the Salyut 6 orbital station. Studies on the effects of weightlessness and other spaceflight factors on living systems predominated. Experiments on tissue and microbe cultures did not reveal any harmful effects of weightlessness on such cultures or on intracellular processes. Similarly, biochemical and morphological studies of animal systems did not reveal any pathological changes induced by weightlessness. Structural-functional changes seen in the musculoskeletal systems were found to be reversible. Experiments performed by the international crews to examine the body's adaptation to weightlessness are described. The period of "acute adaptation" (first 7 days) of the cardiovascular system was the subject of particular attention. The psychological adaptation to weightlessness was also examined, and was found to consist of specific readjustments in psychic activity. Finally, joint studies relating to radiation safety are described.

*Key words: Interkosmos program, Salyut 6, accomplishments*

A book by Alekseyev and coworkers (1981) details the history and accomplishments of the Interkosmos program of manned flights aboard the Salyut 6 station through the conclusion of the second prime mission. The emphasis is on those experiments utilizing specially designed equipment, and on examples of intercooperation between members of the main expeditionary crews and the visiting international crews from various Soviet bloc countries.

*Key words: cosmonautics, history, achievements, future missions*

A lengthy review article in *Izvestiya* by A. Aleksandrov (1981), president of the USSR Academy of Sciences, describes the history and achievements of cosmonautics and their relationship to scientific, social, and economic progress in the Soviet Union. While much of the emphasis is on accomplishments in geophysical, space, and space technology research, an overview of biological and medical research in space is also presented. Plans for the extended application of space research and technology in the service of national economic interests are discussed, along with plans for extended missions directed at solar system exploration.

## Cardiovascular System

*Key words: lower body negative pressure, inflight/postflight reactions, linear discriminant function*

Because of the large number of hemodynamic parameters recorded during lower body negative pressure (LBNP), it is desirable to have a means of expressing the overall evaluation of the reaction to LBNP by a single digital value. Based on procedures currently in use with orthostatic testing, Voskresenskiy and associates (1981) used linear discriminant functions (LDF) to analyze the dynamics of cosmonauts' reactions to LBNP during and after long-term flights. Nine hemodynamic parameters were measured to comprise two classes of observations: those made during flight and postflight. LDF functions derived from these data provided a basis for comparison of other, similar measures selected according to different parameters of interest. Analysis of a control sample of LBNP reactions (Salyut 4), for example, showed that there were no unidirectional changes in flight or major individual differences in evaluation of the two crewmembers. LDF combines different types of data in an optimal way by allowing a weighting of different parameters. Because correlation comparisons are highly accurate and reliable, the use of LDF increases the objectivity with which reactions to LBNP can be scored.

## Hematology and Immunology

*Key words: erythrocyte metabolism, adaptation, spaceflight factors*

Changes in many hematological parameters occurring in spaceflight have been extensively studied, but there has been little work on the metabolism of red blood cells under such conditions. Accordingly, Ushakov and coworkers (1981) examined erythrocyte metabolism of cosmonauts before and after completion of short-term (1 wk; Salyut 6) and long-term (30, 63, 96, 140, and 175 days; Salyut 4 and 6) missions. Parameters studied included ATP and intensity of glycolytic activity of the enzymes lactate dehydrogenase (LDH) and glucose-6-phosphate dehydrogenase (G-6-PDH). No changes were seen in any of these parameters after the 1-wk flight. On the longer flights, however, consistent changes dependent on flight duration were seen. After the 30- and 63-day flights glycolytic activity was found to have declined while ATP content remained unchanged. Crewmembers of the 96-day flight demonstrated a significant decrease (50-60%) in ATP content with more intensive glycolysis (LDH activity only), which was tentatively attributed to engagement of compensatory mechanisms in response to spaceflight factors. After the 140-day flight a decline in intensity of metabolism continued through the first postflight day. Changes after the 175-day flight were similar to those seen after the 96-day flight, with a decline in ATP content against the background of more intensive glycolysis. The authors assert that the changes seen in long-term flights are probably adaptive, and do not reflect impairment of the basal metabolic processes in erythrocytes.

*Key words: fibrinogen concentration, cosmonauts, water immersion subjects*

Fomin (1981) measured and compared the concentration of fibrinogen in the blood of individuals subjected to spaceflight (4 and 7 days) and water immersion (7 days). Using a microtechnique based on the phenomenon of heat denaturation of fibrinogen, they found moderate fibrinogenemia in all subjects. Returned cosmonauts showed a relatively greater degree of hyperfibrinogenemia than did the water immersion subjects. In both subject categories, the fairly high coefficient of correlation between concentration of fibrinogen and hematocrit number (determined with the use of the microtechnique) suggested that hemoconcentration could be one of the causes of the increase in blood fibrinogen. In the course of these experiments, the micromethod that was applied was shown to be simple to use, fast, and adequately accurate.

## Nutrition

*Key words: diet, nutritional status, Salyut 6*

A paper by Bychkov, Kalandarov, and coworkers (1981) describes the use of advanced space diets by the prime crews who made 96-, 140-, and 175-day flights aboard Salyut 6. Preliminary studies of this diet were undertaken to confirm its adequacy under simulated spaceflight conditions. The main features of the diet in comparison to those previously used were: (1) more calories (3150/day, max.), (2) greater assortment of foods, (3) more foods that could be warmed, (4) reconstitution with hot water of dehydrated foods, (5) delivery of fresh foods by cargo ship. All crews found this improved diet to be adequate and appetizing, especially in comparison to previous diets. The nutritional status of the first (96-day) crew was rated as adequate. The status of the second (140-day) crew, as well as their general condition, was considerably better; this is attributed to their more adequate use of exercise and other preventive measures. The nutritional status of the crew of the even longer 175-day mission was judged to be as good or better.

*Key words: space diet, developmental history, improvements, objectives*

An article by Popov (1981) describes the gradual process of development and improvement which the diet of cosmonauts has undergone during the course of the manned flight program. Beginning with the brief flight of Gagarin, in which the first food was ingested in space, and continuing on through the Vostok and Soyuz series to the long-term Salyut missions that were recently completed, the objectives have remained essentially the same: to refine the food rations to the point at which they have maximum acceptability, palatability, convenience, and nutritional adequacy. The most important criterion has been that the food provided meet the full energy requirements of the cosmonauts and provide all needed substances in a maximally assimilable form. As mission length has increased, the psychological acceptability of rations has become almost equally important. New methods of packaging and presentation (hot, reconstituted, fresh) are being devised to improve taste and ease of use, and to ensure that the space diet resembles the crewmember's normal diet as closely as possible.



## Microbiology

*Key words: antibiotics, lactobacilli, sensitivity, resistance, spaceflight factors*

The use of antibiotics to control microflora of cosmonauts during long-term missions raises the possibility of dysbacteriosis, particularly among intestinal lactobacilli. Lentsner, Tyuri, and associates (1981) studied the antibiotic sensitivity of different strains of lactobacilli isolated from saliva and feces of cosmonauts before and after short- and long-term flights. Sensitivity to 10 antibiotics of 411 strains of lactobacilli was tested. The microflora were found to be the most sensitive to penicillin and erythromycin, and the most resistant to polymyxin and gentamycin. Certain antibiotics (vancomycin, ristomycin) had a selective resistance effect among different strains of lactobacilli. No differences in sensitivity were found in the lactobacilli of different cosmonauts, nor were any differences in pre- and postflight sensitivity noted. Lactobacterin is recommended for use before and after inflight antibiotic therapy in order to correct undesirable changes in intestinal microflora.

*Key words: lactobacilli, species composition, antagonistic properties, lysozyme activity*

Lactobacilli are resident microorganisms which play a substantial role in implementing the protective function of microflora with regard to pathogenic viruses. This is thought to be related to their antagonistic properties in relation to other microorganisms, and to their production of lysozyme. Lentsner, Lentsner, Mikel'saar et al. (1981) investigated these and other biological properties of lactoflora isolated from cosmonauts, as well as their species composition. Sixteen tests of physiological and biochemical properties were performed. The antagonistic properties were tested against *E. coli* and other bacteria; 83.6% of the 496 strains tested presented antagonistic activity. Only one strain, *L. fermentum*, produced lysozyme. It was shown that the theory of reduction of species composition in a closed environment does not apply to lactoflora. No significant changes in biology or species composition were shown over 8-, 30-, or 63-day flights. Indications were found that the transfer of lactobacilli among crewmembers cannot be ruled out, and that the probability of such transfer increases with greater mission duration.

## Neurophysiology

*Key words: otolith reflex, spatial perception, adaptation, readaptation*

Yakovleva and Kornilova (1981) studied the reactions of the vestibular system and the space perception function to short- and long-term flights in 24 cosmonauts. The cosmonauts were questioned as to their inflight reactions, and pre- and postflight measurements of the otolith reflex and spatial coordinate perception were made. It was found that 90% of the subjects experienced illusory reactions inflight, while 50% experienced some degree of autonomic discomfort. Postflight, all subjects evidenced statokinetic disorders in walking. Changes in otolith function were observed in nearly all subjects, most often in the form of hyperreflexia and asymmetry reaching 8-14°. The accuracy of spatial coordinate perception was disrupted in all cosmonauts after long-term

missions, and in half after short-term flights. All shifts observed were more pronounced after long-term missions. The authors explain the increase in otolith reactivity on the basis of reaction to the stimulus of gravity after "deafferentiation" in weightlessness. Observed shifts in spatial perception are ascribed to complex disorders in the coordinated activity of sensory systems. Both peripheral and central vestibular formations are tentatively implicated in these disturbances, along with changes in neurohumoral regulatory mechanisms and hemodynamic shifts associated with the adaptation to weightlessness and postflight readaptation.

*Key words: space motion sickness, vestibular apparatus, otolith function, dynamic factors*

An article by Lapayev and Pavlov (1981) reviews investigations by Soviet and foreign scientists of shifts in the functional condition of the vestibular apparatus brought about by the dynamic factors of spaceflight. The authors summarize several theories which explain the etiology and pathogenesis of adverse reactions, predominantly vestibular, which develop in cosmonauts. The primary spaceflight factors affecting the functional condition of the vestibular analyzer are weightlessness and acceleration. The latter may include Coriolis acceleration, rotation, linear acceleration at launch, and angular accelerations of different intensities produced by head movements and unstabilized flight of the spacecraft. The effects of such accelerations may be intensified by increased excitability of the receptor formations of the semicircular canals brought about by functional shutdown of the otolithic apparatus. Speculations regarding the contribution of disturbances of the spatial analyzers and the vagus nerve in space motion sickness are noted. Other spaceflight factors that may play a role are modified gaseous atmosphere, noise, and vibration. Findings concerning these factors and their effects are also reviewed.

## **Psychology**

*Key words: long-term habitation, problems*

An article in the journal *Air & Cosmos* (Anonymous, 1981b) summarizes a report by General V. Shatalov, chief of the Soviet cosmonaut corps, concerning psychological problems that must be surmounted before extremely long-term stays in space become feasible. Shatalov cites weightlessness and the limitation of living space, social contact, and information as factors contributing to the central problem of boredom and fatigue due to the rigid routine of long-term habitation in space. Another important consideration is the need to free the cosmonauts from the necessity of monitoring systems which could be controlled from the ground. Shatalov believes that the search for solutions to these problems "will require more than a year."

## **Clinical Aspects of Crew Health**

*Key words: pathogenic staphylococci, carriers, prophylaxis*

Pathogenic staphylococci are expected to be the most likely transmitters of infectious diseases aboard spacecraft. To investigate possible methods of prevention, Zaloguyev, Viktorov, and

coworkers (1981) examined the incidence of carriers of pathogenic staphylococci among prospective cosmonauts, and assessed the changes in those microflora among carriers while engaged in spaceflight. Sites tested were the nose, mouth, and integument. Pathogenic staphylococci were found on the upper respiratory mucosa in 72% of the subjects, while they were present in both nose and mouth in 48%; they were rare on integumental surfaces. Repeated testing revealed that over half of the carriers were constant carriers. During spaceflight, some changes in composition of staphylococcal flora were seen—increase in size of microbial focus, increase in antibiotic-resistant strains—as well as transmission between crewmembers. These findings make it necessary to treat carriers; yet prophylaxis is difficult. Antiseptics elicit only a brief effect. Antibiotics are contraindicated because of the prevalence of multiple-resistant strains. Bacterial interference is not yet a proven technique; and immunization with staphylococcal antitoxin is ineffective. The authors suggest as a promising route the search for means of mobilizing nonspecific resistance to infection via activation of biosynthesis of class A secretory immunoglobulins.

## Space Biology

### Musculoskeletal System

*Key words: osteoporosis, artificial gravity, Cosmos 936, rats*

Stupakov (1981) used a centrifuge to test the effectiveness of artificial gravity in preventing the development of osteoporosis in rats flown aboard Cosmos 936. The weight, volume, and mineral content of tibias of centrifuged and weightless rats were measured, along with those of synchronous control animals on the ground. It was found that relative losses of bone mass and volume were the same in the centrifuged rats as in synchronous controls, i.e., no osteoporosis was seen, although significant osteoporosis was found in the weightless group. Evidence indicates that development of osteoporosis in rats during spaceflight is due to the effect of weightlessness rather than confinement. The osteoporosis seen in weightless flight rats was found to be reversible (after 25 days).

*Key words: antigravitational muscles, contractility, Cosmos 936, rats*

The functional atrophy of muscles and adaptive transformation of their contractile properties seen after spaceflight might reflect not only structural and metabolic changes, but changes in contractile properties of myofibrillar proteins as well. Oganov, Skuratova, and Shirvinskaya (1981) studied the contractility of glycerinated muscle fibers taken from muscles of the front (brachial triceps and brachial muscle) and hind (soleus and extensor digitorum longus) legs of control rats and rats flown aboard Cosmos 936. In general, results indicate that the reaction of the contractile system of different muscles to spaceflight factors is determined, to a considerable extent, by the functional specialization of the muscles involved, and by biomechanical conditions for their contraction. In slow antigravitational muscles (soleus and brachial triceps), for example, a decrease in the amplitude of isometric tension and performance and an acceleration of contractile development were observed. The authors suggest that changes in contractile properties of myofibrillar proteins may contribute to the adaptive rearrangement of functional properties of antigravitational muscles during spaceflight.

*Key words: muscle fibers, atrophy, microcirculation, ultrastructure, Cosmos 605 & 782, rats*

It is thought that microcirculation may play an important role in the pathogenesis of atrophic changes in muscle fibers in weightlessness. To investigate this possibility, Savik and Rokhlenko (1981) used electron microscopy to study the ultrastructure of blood vessels and muscle fibers of extensor muscles (soleus and gastrocnemius) of rats flown aboard Cosmos 605 and Cosmos 782. Ground-based synchronous and vivarium controls were used. It was found that orbital flight did not cause significant microcirculatory disturbances; however, atrophy of muscles was seen immediately postflight, along with a reduction in the number of functioning capillaries. These changes can be attributed to restricted activity and absence of static load, rather than to impairment of vascular wall structure. Readaptation to 1 G (48 hrs postflight) led to marked changes in the soleus vascular system: increased permeability of capillary and venular walls and edema of the perivascular connective tissue. These disturbances may be one of the sources of atrophic and dystrophic changes in muscle fibers that are also seen in the readaptation period.

### Metabolism

*Key words: catecholamines, adrenomedullary system, weightlessness, stress, Cosmos 936, rats*

It has been shown that epinephrine content of rat adrenals decreases under acute stress and increases under chronic stress, along with an increase in catecholamine (CA) biosynthesis and activity of CA-synthesizing enzymes. Kvetnyanski, Torda et al. (1981) measured CA content and activity of enzymes tyrosine hydroxylase (TH) and dopamine- $\beta$ -hydroxylase (DBH) in rat adrenals after flight aboard Cosmos 936 in weightlessness and centrifugation. These indicators showed that there was no appreciable change in activity of the adrenal medulla in the course of a long-term (19.5-day) flight. The absence of change in TH activity suggests that prolonged exposure to weightlessness does not act as a strong stressor of the rat adrenomedullary system.

*Key words: sarcoplasmic proteins, myosin, enzymatic activity, artificial gravity, Cosmos 936, rats*

Changes in the enzymatic activity of the contractile protein, myosin, in the rat myocardium have been noted following long-term spaceflights. Tigranyan and associates (1981) used centrifugation to determine whether artificial gravity would prevent such metabolic changes in the myocardium of rats. In weightless rats the content of sarcoplasmic proteins increased immediately after recovery, and there was a slight decrease in T fraction proteins 25 days postflight. These changes were not seen in centrifuged rats. The enzyme activity of sarcoplasmic proteins did not change in any of the flight or control groups. However, the ATPase activity of myosin decreased significantly in weightless rats, while in centrifuged rats it remained nearly unchanged. Thus, the use of artificial gravity during flight eliminated to a significant degree the effect of weightlessness on myosin activity.

*Key words: glycolysis, pentose phosphate pathway, muscle activity, Cosmos 936, rats*

Glycolysis is one means by which the energy requirements of muscle tissue can be met. Most glucose metabolism takes place in muscle tissue, with conversion of glycogen via the pentose phosphate pathway (PPP) ordinarily accounting for a negligible share of the process. However, when there are substantial changes in the functional state of muscle fibers, a drastic increase in the activity of enzymes involved in the PPP usually takes place. Therefore, the activity of those enzymes can be used to indicate the metabolic state of different muscle tissues. Nesterov, Veresotskaya, and Tigranyan (1981) investigated both PPP enzyme activity and carbohydrate-phosphorus metabolism in skeletal muscles of rats flown aboard Cosmos 936. No change was found in the activity of glycogen phosphorylase and adenylate cyclase in muscles after spaceflight. The activity of glucose-6-phosphate and 6-phosphogluconate dehydrogenases (PPP enzymes) increased noticeably in the most active skeletal muscles, the gastrocnemius and tibialis anterior. The authors interpret activation of the PPP reaction as being associated with processes compensating for muscle damage caused by insufficient function.

*Key words: skeletal muscles, metabolism, artificial gravity, Cosmos 690 & 782, rats*

Both atrophy and dystrophy of skeletal muscles have been demonstrated in rats subjected to weightlessness and/or confinement. Nosova and coworkers (1981) conducted studies to determine whether artificial gravity would prevent metabolic changes that occur in skeletal muscles under weightless conditions. The quadriceps, soleus, and gastrocnemius muscles of rats flown aboard Cosmos 690 and 782 were examined for changes in protein fractions, phospholipid content, myosin ATPase activity, and activity of certain enzymes. Metabolic reactions of muscles to weightlessness were found to differ according to the function and fiber composition of the muscle. Corresponding differences were seen during the period of readaptation to Earth's gravity. The use of artificial gravity was found to prevent metabolic changes that occur specifically in response to weightlessness.

*Key words: amino acid content, protein synthesis, Cosmos 1129, rats*

A paper by Vlasova and coworkers (1981) presents data concerning the free amino acid content of rats flown aboard Cosmos 1129. Because such information relates to the intensity of protein synthesis in muscle tissue, it can be used to search for ways of optimizing protein metabolism and regulatory mechanisms under extreme conditions. The study revealed consistent changes in the composition of the amino acid pool after the 18.5-day flight. There was a decline in the concentration of tested amino acids (isoleucine, threonine, serine, phenylalanine, glutamic acid, glycine, and others) such that total postflight amino acid content constituted 74.4% of that in vivarium controls. Total amino acid content in synchronous ground-based controls was essentially the same as in vivarium controls. These changes appear to be associated with the selective rate of incorporation of free amino acids into the biosynthetic processes during the period of acute adaptation, and with alterations in the protein synthesis rate.

## Genetics

*Key words: development, morphoses, dominant lethals, Salyut 6, flour beetles*

Flour beetles present certain definite advantages for developmental studies in space: precise methods of genetic analysis have been worked out for them; the nutrient medium (flour) is safe, inexpensive, and spoil-proof; their developmental cycle has a precise length at various temperatures; and they can be densely cultured. Parfenov (1981) describes a number of previous studies of the effects of spaceflight factors on various parameters of flour beetle development, and presents the results of an experiment he conducted with flour beetles flown aboard Salyut 6. The extended duration of missions aboard the orbital station made it possible to examine an entire cycle of development. Survival of specimens in every stage of the life cycle, duration of development, and frequency of wing morphoses in imagos were assessed. None of these parameters in flight insects differed significantly from their values in ground-based controls. Beetles developed in weightlessness without any appreciable disturbances, and weightlessness did not induce genetic changes in gametes. These experiments confirm findings with other insects to the effect that, with the meroblastic type of cleavage at least, changes in gravity do not affect development so long as the structural integrity of the embryo is preserved.

## Neurophysiology

*Key words: joint receptors, spaceflight factors, Cosmos 782 & 690, Soyuz 20, turtles*

In order to obtain basic information on the effects of spaceflight factors on the functioning of the joint receptor apparatus, Drobyshev and Makarov (1981) studied the shoulder, elbow, pelvis, and knee joints of 40 turtles flown aboard Cosmos 690, Cosmos 782, and Soyuz 20. After a 19.5-day flight on Cosmos 782, an increase in the number of joint receptors showing reactive changes was observed. Such changes were more pronounced after a longer flight aboard Soyuz 20. It was found that doses of ionizing radiation on the 10th day of the 20-day Cosmos 690 flight caused an intensification of these changes.

## Psychology

*Key words: learning ability, artificial gravity, Cosmos 936, rats*

The imposition of artificial gravity in weightlessness, since it tends to normalize some neuro-motor functions in rats, might be expected to have a positive effect on learning ability as well. Livshits, Apanasenko, and associates (1981) studied the formation of complex behavioral skills (learning a maze) in both weightless and centrifuged rats, at a point 18 to 24 days after flight aboard Cosmos 936. Control animals on Earth were subjected to similar conditions. Results were processed by regression analysis. The analysis indicated that centrifugation had worsened the postflight ability of flight rats to assimilate new behavioral skills; it took them longer to master the maze. The authors attribute this result to the effect on the vestibular analyzer of angular velocities present in centrifugation.

*Key words: higher nervous activity, maze performance, spaceflight factors, Cosmos 782, rats*

Livshits, Meyzerov and coworkers (1981) investigated changes in higher nervous activity (HNA) occurring in rats flown aboard Cosmos 782. Preflight tests of maze learning and performance ability were conducted on experimental and laboratory control rats. After flight, both groups of rats were put through a number of tests at different postflight periods, using the same maze as before. The flight rats were somewhat superior to control animals in their performance on these tests: they were not as distracted by the sounding of a bell, they endured an increased functional load (greater number of test runs) better, and were slightly superior in transfer of experience to the learning of a modified maze. When they were presented with a more complicated maze on the 21st-25th days postflight, both groups of rats performed the same on the first run; however, on the second run the flight rats did not perform as well. These results indicate that the linking function of the cerebral cortex is preserved postflight, so that performance in familiar circumstances and transfer of experience to a similar situation are not impaired. The initial ability to develop new and more complex behavior patterns is likewise unaffected; but the ability to retain that new knowledge is decreased. This indicates depletion of the main nervous processes of the central nervous system, probably as a compensatory reaction to stress, ionizing radiation, and other space-flight factors.

## **Plant Research**

*Key words: space greenhouse, higher plants, biological barriers, Salyut 6*

An article by Yudin (1981) examines the current status of Soviet attempts to develop a bioengineering life support system, or "space greenhouse." The concept of a bioengineering system is defined as including both biological and biophysical links, so as to compensate for the different metabolic rates of the various components of the system. The potential for use of both higher and lower plants is discussed. Apparent "biological barriers" have been encountered in the growth and development of higher plants, especially at the stage of flowering and seed formation. Attempts to overcome these obstacles by experimentation aboard Salyut 6 are reviewed: the *Malakhit* greenhouse, the *Oasis* cultivator, and the *Svetoblok* instrument all represent attempts to find ideal conditions for the development of higher plants in space. The use of electrical stimulation in ground-based clinostat experiments has given promising results, as has the *Biogravistat* centrifuge. The author is optimistic that space greenhouses will eventually be successfully developed.

## **Life Sciences Technology**

### **Bioinstrumentation**

*Key words: elevator reaction, latency period, measurement, rats*

Ayzikov and coworkers (1981) report their development of a device for measuring the latency period of the elevator reaction (LPER) of rats after long-term spaceflights. This reaction is a form

of otolithic-spinal reflex which occurs in response to vertical motion (particularly free fall), and which can be used to determine the integrity of dynamic otolith function. The device consists of an animal container held in place on a vertical rod by electromagnetic force. When the current is cut, the container falls; simultaneously a timer begins running. Part of the rat's elevator reaction is to extend its limbs and arch its back. Operation of the device depends on this reaction, which lifts the container's lid and breaks a circuit, stopping the timer. The authors established the experimental procedures and determined the normal value of LPER in Wistar rats:  $28 \pm 6$  msec. The device was developed for use with rats flown aboard Cosmos 936 and Cosmos 1129. An important goal in experimentation of this type is determination of the role of the vestibular and motor components of the elevator reflex in the immediate postflight period.

*Key words: radiation dosimeter, dose sensitivity, dose power sensitivity*

Radiation monitoring in space requires dosimeters with a high dose sensitivity and low dose power sensitivity threshold. Existing dosimeters are deficient on both counts, and do not permit space-time resolution of the dosage field. Markelov and Red'ko (1981) have designed a highly sensitive dosimeter which employs a silicon diffusion-drift detector. The device has variable dose sensitivity and can operate in a dose power range of from  $2 \times 10^{-7}$  to 0.2 J/kg-hr. Overall measurement error does not exceed 15%. The device was tested in orbital flight of the Intercosmos-17 satellite over the South Atlantic Anomaly. Plots of dose power and dose per particle are shown graphically.

### **Space Cabin Environment**

*Key words: Soyuz T, system improvements, cabin configuration*

An article in a German journal (Anonymous, 1981a) describes the Soyuz T-series spacecraft and discusses the ways in which it differs from the previous generation of Soyuz vehicles, now being phased out. The primary difference is the three-man cabin configuration, which allows for the inclusion of a non-pilot crewmember. A major improvement is the use of a new onboard computer for automated flight control, systems monitoring, and data transmission. This system significantly unburdens the flight crew, particularly in the area of routine and repetitive tasks. A third improvement is the use of a centralized propulsion and control system, with the main and vernier engines now using a single fuel. A photograph of the cabin interior is included.

### **Flight Control Experience**

*Key words: space astronavigation, techniques, human operator characteristics*

A monograph by Bykovskiy, Merkulov, and Khachatur'yants (1981) examines the developing field of space astronavigation. Major topics are: different types of equipment, methods of assessing the accuracy of astronavigation techniques, and analysis of the cosmonaut's role and performance



in astronavigation. Important differences and similarities between astronavigation in the aviation and space environments are described. A number of devices are noted that can be used to correct errors inherent in the use of inertial guidance systems. These include astrotelescopes, a Doppler flight speed/altitude indicator, true local vertical indicators, and visual optic devices for determining orientation with regard to celestial points of reference. Of these, the latter is the most acceptable given current constraints on size, weight, and energy consumption aboard spacecraft. A semi-automated, self contained astronavigation system utilizing man must take into account his psychophysiological characteristics and limitations. Emphasis is placed on this type of system and its requirements.

*Key words: spacecraft automated control system, cybernetics*

Smirnov (1981) describes the Earth-space vehicle control system that is employed to control the operation of space vehicles. Design and optimization of this complex network of ground-based support systems, onboard systems, and information links is viewed as comprising a new branch of engineering cybernetics. Chapters deal with time-space and functional characteristics of space vehicles, the configuration of elements of the command/measurement complex, and operational data processing and analysis.

### Exobiology

*Key words: Venus atmosphere, gaseous composition, mathematical model*

Krasnopol'skiy and Parshev (1981) used data from the Pioneer and Venera-12 probes to construct a mathematical model of the neutral composition of the atmosphere of Venus at altitudes ranging from 50 to 200 km. The model determines the concentrations of  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ ,  $\text{HCl}$ , and  $\text{SO}_2$  photolysis products as a function of altitude, overcoming certain deficiencies of previous models such as the artificial separation of sulfur and chlorine compounds. Particular attention is devoted to the  $\text{CO}_2$  and  $\text{CO}$  equilibrium at altitudes of 50-100 km. Good agreement is shown between the predicted  $\text{HCl}$ ,  $\text{SO}_2$ , and sulfur concentration curves and probe data. Detailed graphs present the breakdown and formation rates, as a function of altitude, of  $\text{O}_2$ ,  $\text{H}_2\text{O}_2$ ,  $\text{O}_3$ , and  $\text{C}_2$ , in addition to the other compounds mentioned above.

*Key words: Venus atmosphere, aerosol component*

Drawing on scanning photometric and spectrophotometric data collected by Venera-11 and -12, Golovin, Moshkin, and Ekonomov (1981) discuss the structure of the aerosol component of the atmosphere of Venus at altitudes of 10-63 km. (Below 10 km, molecular scattering plays the decisive role in sunlight attenuation.) The author draws a number of conclusions about the atmosphere's optical depth and coefficient of extinction, and about the optical thickness of the cloud cover.

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